THE PLANT ECOLOGY OF PART OF THE MOUNT LOFTY RANGES (1)

By R. L. Specht and R. A. Perry *

[Read 10 June 1948]

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* Department of Botany, University of Adelaide.

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INTRODUCTION

This paper deals with the ecology of that part of the Mount Lofty Ranges between the Torrens Gorge in the north and Noarlunga in the south.

The area surveyed by Specht lies between the Torrens Gorge in the north, grid line 80 of the Adelaide and Echunga ordnance map in the east and grid line 68 in the south, while Perry surveyed the area from grid line 68 in the north to 52 in the south extending east from the coast to grid line 68.

The only previous ecological work on this area was a reconnaissance survey by Adamson and Osborn (1). As can be expected from reconnaissance survey, some generalisations were made which probably apply to part of the Mount Lofty Ranges but not necessarily to the whole. Adamson and Osborn did not publish any vegetation map, nor did they indicate in the text the exact localities studied. Since then detailed work on the soils of the southern portion of the Hundred of Kuitpo, by Taylor and O'Donnell (21) and on the geology by Sprigg (17, 18, 19) form a useful background to this study of ecology.

Considering the limited size but complexity of the area, it was deemed necessary that the ecology should be approached from a study of the autecology of the dominant tree species and of the formations. With this in view the distribution of the tree species and formations was mapped by projecting their limits on a contour map. As many factors as possible of the environment were examined and attempts were made to correlate the distribution of the species with the environment. The soils were surveyed by borings at each grid intersection on the ordnance survey maps, i.e. at approximately 1,000 yard intervals.

Because of the complexity of the environment the study of the vegetation could be regarded as a number of specially designed experiments in which possibly only one factor at a time was variable. For instance, it was found that soils of different nutrient status occurred contiguously under the same climatic conditions, while soils of one group extended from regions of low to high rainfall. Of course, any generalisation can only be accepted on the understanding that it may not necessarily apply to other areas of the Mount Lofty Range. However, although other surveys of the ecology of this State have been of rather a broad nature in comparison, they have yielded conclusions roughly similar to some suggested in this survey. These have been indicated in their appropriate places within the text. It must be pointed out that in dealing with the trees whose roots tend to penetrate to great depth, the early stages of growth are considered crucial in their development within the environment in which they are found.

As most of the soils throughout the area are extremely poor most of the area has been left relatively undeveloped. It is only along the coastal parts in the south, the Adelaide Plains and fertile valleys and ridges of the Hills, that much agricultural development has taken place. Most of the soils of the coastal area are planted with vineyards and orchards, but some cereals are grown. The Adelaide Plain, although now closely settled, was once an extensive cereal growing area, while the small fertile portions of the hills are planted with orchards, vegetables and some pastures. The savannah woodlands are used in their natural state for grazing.

TOPOGRAPHY

The area forms part of an original extensive peneplain which has been block-faulted during the Kosciuskan period (probably Pleistocene) and subsequently dissected by three major stream systems—namely from north to south, the Rivers Torrens, Sturt, and Onkaparinga.

Creeks named First, Second, Third, Fourth, Fifth and Sixth Creek form the major tributaries of the River Torrens, and Cox's, Aldgate and Scott's Creeks flow into the River Onkaparinga. Both the River Torrens and the Onkaparinga are part of the old river systems present before the faulting occurred. They must have been large enough to keep pace with the rise in level due to faulting and have cut meandering gorges up to 500 feet in depth. Smaller creeks such as Brownhill, Christie's and Reynella Creeks aid the drainage of the area.

In the southern section of the area three distinct faults are present. The land rises sharply from the gently rising Adelaide Plains along the Eden

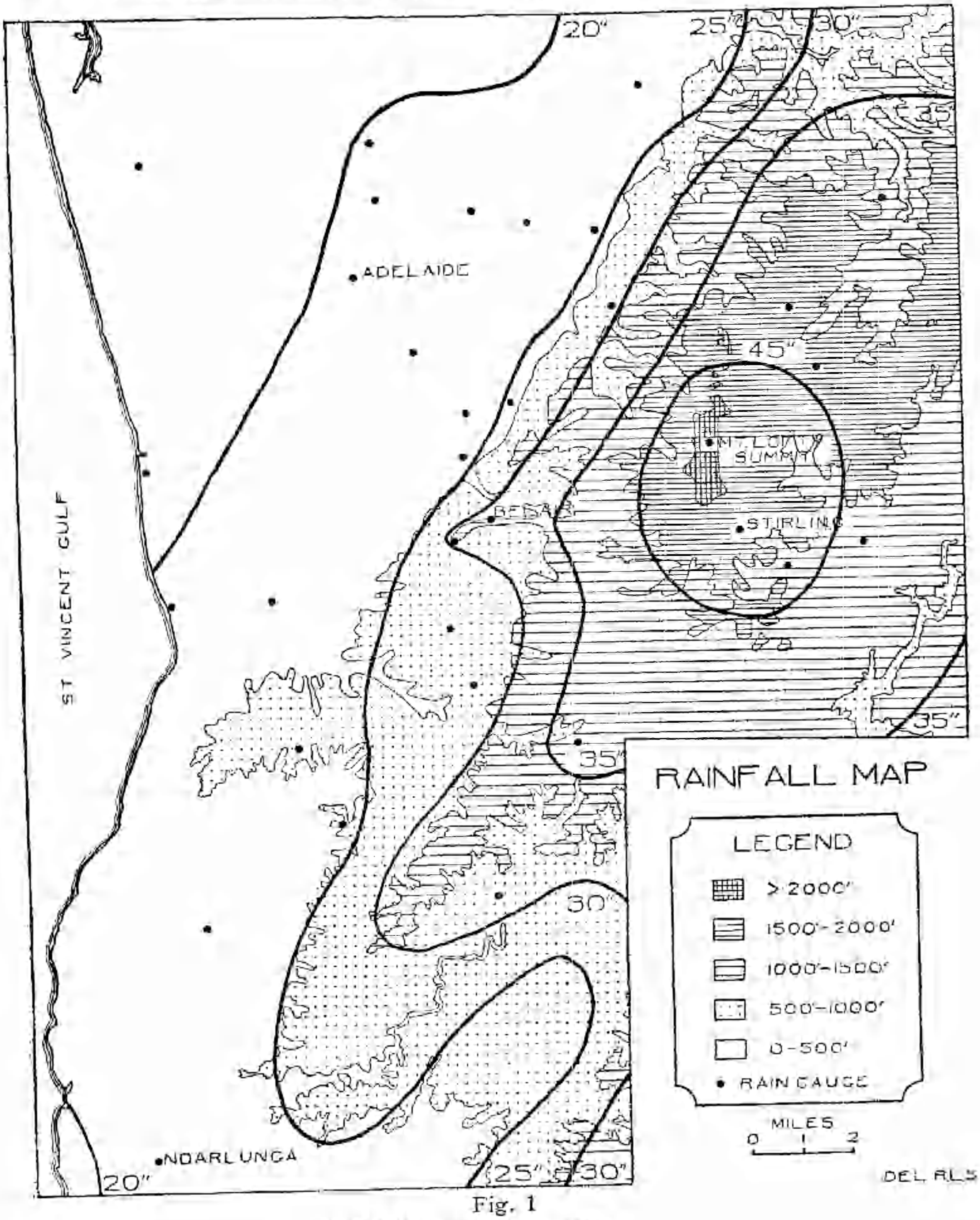


Fig. 1
Rainfall and altitude map.

fault (with a throw of 600 to 700 feet) on to the Eden-Moana Block, again at the Ochre Cove Fault Block and still again with a throw of 700 feet along the Willunga Fault. The original peneplain level gradually slopes to the south-west along these three fault blocks, the level of the Ochre Cove Fault Block in particular dropping from 1,200 feet north of Clarendon to 400 feet near Noarlunga. In the northern section, however, only the Eden Fault is prominent but the topography is complicated by the indistinct extremities of the Ochre Cove and Kitchener Faults, while the Burnside Fault occurring a little to the west of the Eden Fault aids in confusion. The monadnock structure of Mt. Lofty, which rises to 2,234 feet, dominates the topography.

A general idea of the topography can be gained from the rainfall map on which contours for the 500 feet level and multiples thereof are indicated (Fig. 1). The dissection is influenced by the nature of the rock, the slates and phyllites giving more rounded and gentler sloping ridges than those developed in the less rapidly weathering quartzites. Plate V shows a photograph of a model made of the central section of the area.

GEOLOGY

Sprigg's Reconnaissance Survey of the Geology of the Mt. Lofty Ranges (between the rivers Sturt and Torrens) (19) and the Geology of the Eden-Moana Fault Block (17) gives a detailed account of the geology of the area.

The undermass rocks consist of a series of Pre-Cambrian sediments, called the Adelaide Series, which have been extensively faulted and folded.

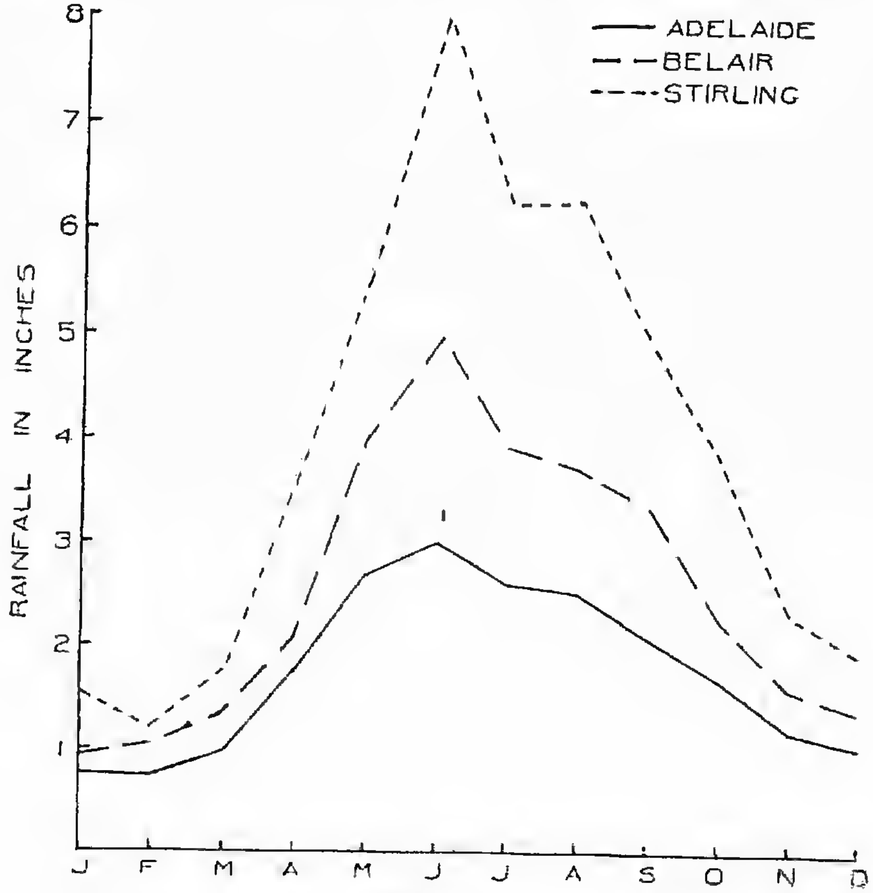


Fig. 2
Mean monthly rainfall at Adelaide, Belair and Stirling.

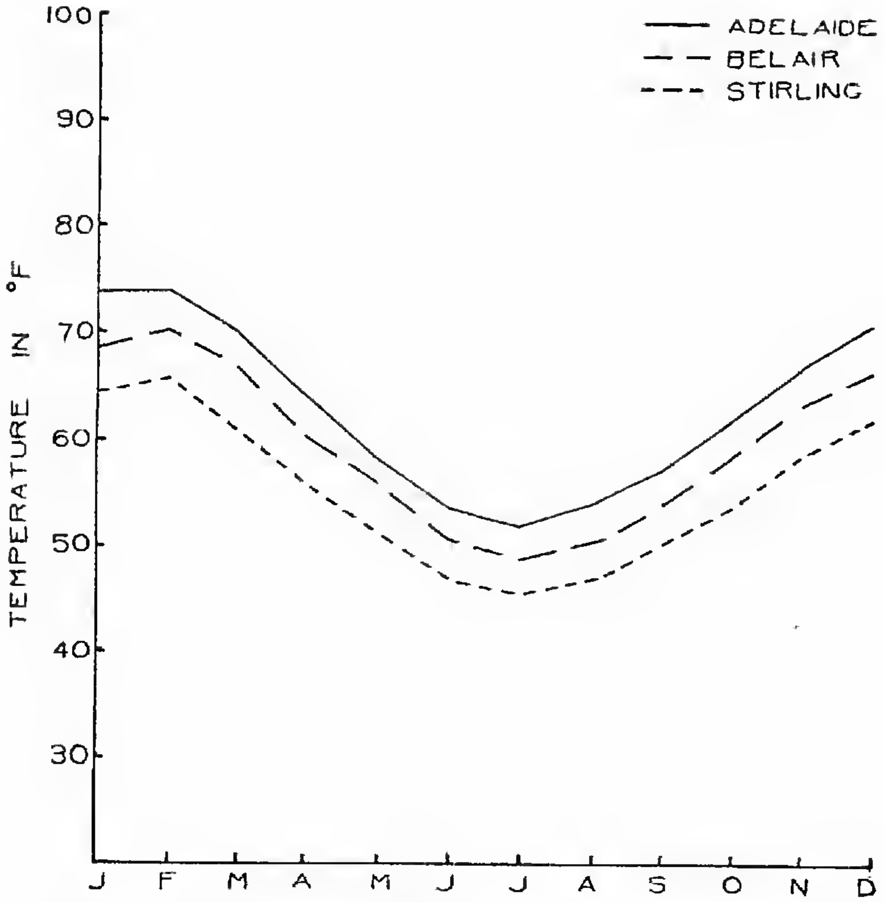


Fig. 3
Mean monthly temperature at Adelaide, Belair and Stirling.

Of importance to the ecology of the area are the metamorphosed rocks of the Barossian Complex, the sandstones, quartzites and phyllites of the Lower Adelaide Series (the easterly half of the area) and the slates, Sturtian tillite and flaggy slates and quartzites of the Upper Adelaide Series (the westerly half).

Overlying the Adelaide Series on the Eden-Moana Fault Block from Blackwood to Happy Valley Reservoir are remnants of a lacustrine deposit of consolidated Oligocene sands on the old peneplain surface. In addition large areas of Miocene marine sediments, mainly marls and limestone, and limited areas of Pleistocene raised sea beaches occur on this block.

Since the Pleistocene the Torrens River and Brownhill Creek systems have built up the large alluvial deposits of the Adelaide Plain with material dissected from the fault blocks to the east.

In recent times the River Onkaparinga has developed an extensive alluvial flood plain which extends several miles inland from its mouth.

CLIMATE

The meteorological data available from stations within and adjacent to the area suggest that there is a close correlation between altitude and climate. Rainfall data indicate an increase in rainfall with altitude (see rainfall map) rising from 17·94 inches per annum at Glenelg to 47·84 inches per annum on Mt. Lofty Summit, with a deterioration in rainfall to the north and in the rainshadow of Mt. Lofty Summit. This deterioration is caused by the fact that most rains are borne by south-west winds. In all cases February is the driest while June is the wettest month. The data available for Adelaide, Belair and Stirling West show that there is an increase in rainfall and humidity and a corresponding decrease in temperature with altitude (see Figs. 2 and 3).

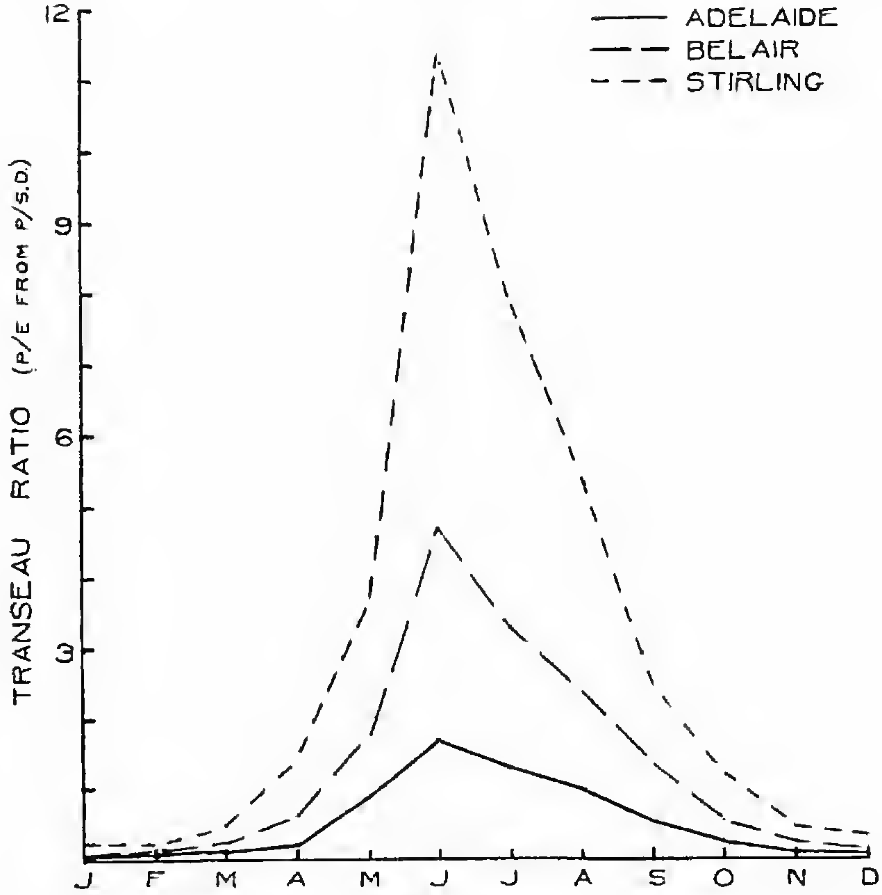


Fig. 4
Mean monthly values for Transeau ratio at Adelaide, Belair and Stirling.

From the average humidity and average temperature, the Meyer and Transeau ratios have been calculated, both of which show an increase with altitude (see Fig. 4). From this data it is seen that Adelaide has an influential rain period (P/E greater than 1/3) for 6·8 months, Belair for 8·5 months and Stirling West for 10·7 months with influential rainfalls of 15·9 inches, 26·3 inches and 45·8 inches respectively (Trumble 23). When Davidson's less accurate P/E greater than 1/2 is used, Adelaide lies within Davidson's warm temperate semi-arid zone while Belair and Stirling West lie within his warm temperate semi-humid zone (10). However, it must be remembered that all the above data give a rough approximation only of the moisture relations within the soil, for the dissection of the country and the water-retaining capacity of the soils play a large part in producing microclimates. Much of the influential rains is lost to the soil as "run-off" into the creeks, which consequently are moister habitats, while a clay soil will tend to retain more moisture than a sandy soil in which most of the water percolates through into the subsoil or to the underlying rock. Hence under the same conditions of physiography and climate a deep sand will tend to be drier than a shallow sand over a clay subsoil which in turn will tend to be drier than a soil with a predominantly clayey profile. It must also be remembered that Trumble (23) in proposing his influential rainfall period as those months with P/E greater than 1/3, based it on the time interval over which the surface soil of the Waite Agricultural Research Institute tends to be maintained above the wilting point for herbage plants. It does not necessarily follow that the same factor of 1/3 holds for all other plants and seedlings.

Insolation has a marked influence in producing microclimates in dissected country; that is the micro-climates are also determined by aspect. Although no attempt has been made to demonstrate this for the Adelaide Hills, the southern sides of the ridges are apparently moister than the northern sides. This is largely due to the direct effect of insolation on evaporation—the sunny, warmer, north-facing slope being drier than the more shaded, cooler, south-facing slope. This difference in micro-climate may also be enhanced by the fact that most of the rain is borne from the south-west (this data is available only for Adelaide but should be similar for the rest of the area), hence giving a minor rain-shadow on the northerly sides of the ridge.

Consequently, with the decrease in temperature with altitude, the figures for Adelaide, Belair and Stirling West indicate that active growth of herbage plants (average monthly temperature less than 55° F) is restricted for 3, 4 and 6 of the winter months respectively, and moderate growth (less than 50° F.) for nil, 1 and 3 months respectively. (Trumble 23).

Hours of sunlight and frosts appear to have little effect on the general vegetation, but may play a part in the agriculture of the area.

From the data presented above it is evident that the area can be roughly divided into at least three main climatic regions, namely:

(1) Country less than 500 feet altitude with an influential rainfall period of 6 to 7 months.

(2) Country 500 to 1,500 feet altitude with an influential rainfall period of 7 to 9 months.

(3) Country greater than 1,500 feet altitude with an influential rainfall period of 9 to 11 months.

with a large number of micro-climates produced within each zone.

SOILS

In the southern two-thirds of the area a reconnaissance was made of the pedology by boring holes approximately 1,000 yards apart, while the remainder of the area was mapped from observations made on profiles exposed in cuttings and by a superficial examination of the soil. As the survey was on a broad scale no attempt has been made to map soil types, the survey being only sufficient to give an outline of the soil groups present.

Where the rocks of the Adelaide Series or overmass sediments are exposed there is a marked correlation between the geology and the soil while, in the south, soils derived from lateritic soils developed on the former peneplain surface tend to predominate.

The soils can be grouped as follows:—

A. Soils derived from Plio-Pleistocene lateritic soils:
    (1) Residual lateritic podsols.
    (2) Truncated lateritic podsols.

   (3) Deep siliceous sands with strongly acid reaction.
   (4) Lateritic podsols under conditions of poor drainage.

B. Soils formed under the present environmental conditions:
   (1) Podsols.
   (2) Grey-brown podsols:
      (a) With high nutrient status.
      (b) With low nutrient status.
   (3) Calcimorphic soils:
      (a) Rendzinas.
      (b) Terra rossas.
      (c) Degraded rendzinas.
   (4) Red-brown earths.
   (5) Ferrimorphic soils (?).
   (6) Deep sands of neutral reaction.
   (7) Miscellaneous soils.

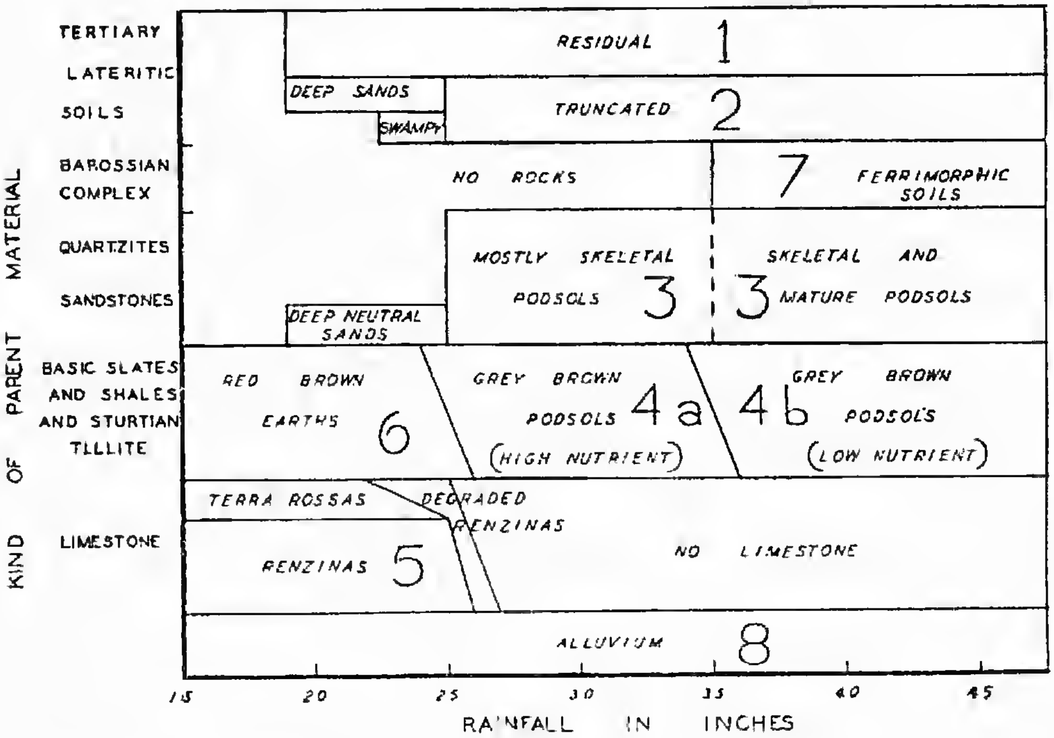


Fig. 5

Diagram showing the soils in relation to rainfall and parent material.

The relation of the soils to rainfall and parent material is illustrated in fig. 5. The parent materials are arranged from bottom to top in decreasing order of base content. Thus, generally, the soils at the top of the diagram have a lower nutrient status and a lower pH than those at the bottom. For the purpose of the diagram, the Tertiary lateritic podsols are regarded as the parent material from which the present-day lateritic soils have been derived.

A. Soils derived from Plio-Pleistocene Lateritic Soils

These soils are relics from a more pluvial climate in the Pliocene when they were developed over most of the former peneplain surface. The profile developed during this period is that of a highly leached podsol in which a seasonally fluctuating water-table produced concretions of ferruginous material near the junction of the sand and the clay horizons. Often ferruginisation appears as pockets through the clay and the parent material (Stephens 20). The lateritic concretions show great variation. In some cases they are massive while, in others, pisolitic gravel and nodules occur. Over the Oligocene lacustrine deposits a ferruginised sandstone or a ferruginised conglomerate of water-worn quartz pebbles occurs in the position of the lateritic concretions in the typical lateritic profile.

However, when faulting broke up the old land surface in the Pleistocene, dissection began and the lateritic profile was truncated to varying degrees. Over most of the area, especially in the northern half, complete truncation down to the parent rock has occurred. Evidence of the former lateritic profile is frequently seen by intense ferruginisation of the rock on the tops of the ridges. These rocks thus exposed have developed soils in equilibrium with the present climate (see below).

Lateritic soils in varying stages of truncation occur on the tops of the ridges which constitute the former peneplain level on the Eden – Moana, Ochre Cove and Willunga Fault Blocks. As shown in the section on topography, all these fault blocks are tilted to the south-west. On the Eden – Moana Fault Block complete truncation of the lateritic profile occurs in its northern limit. At Belair the profile is truncated down to the lateritic gravel (a truncated laterite), the sand of the A horizon having drifted down the gradient to the south-west, or eroded down the valley. At Blackwood a little to the south a shallow sandy A horizon is present, this horizon becoming deeper as we move further to the south, while very deep sands (over six feet deep) occur near Happy Valley Reservoir. It appears that the sand of the A horizon has gradually drifted down the fault block, stripping the profile in the north and accumulating in the south. Of course, much of the sand will be washed away down the valleys, and there is a possibility that the sands were winnowed during the arid period proposed by Crocker (8). Also there may have been a supplement of sand from the higher fault blocks. Hence, consequent to these movements, the results of mechanical analysis (see Appendix I) show that the coarse sand : fine sand ratios of the sand and the clay horizons do not agree as found by Northcote for a residual laterite on Kangaroo Island (12). Similarly on the Ochre Cove Fault Block, the truncated laterite is seen at Cherry Gardens, while further to the south a sandy A horizon, which becomes progressively deeper, occurs. Near Blewett's Springs and McLaren Flat, to the south of the area surveyed, deep lateritic sand accumulations occur. On this fault block the laterite extends for at least 30 miles to the south. On the Willunga Fault Block only truncated laterite has been observed as yet. This truncated laterite has been called Kuitpo gravelly sandy loam by Taylor and O'Donnell (21).

The Bradbury kaolin mine is indicative of truncation of the deep lateritic profile to the pallid clay horizon. In recent times up to 12 inches of grey clayey soil of poor nutrient status has developed over the kaolin.

For convenience the lateritized soils will be divided into four classes, the general profile characteristics of which are illustrated in fig. 6.

1. *Residual lateritic podsols*

This soil is characterised by a coarse sandy surface which may vary from 8 to 27 inches in depth and which contains about 50% of ironstone gravel in the lower six inches. Quartz gravel often occurs with the ironstone. Owing to accumulations of organic matter near the surface the upper few inches are usually dark grey in colour, while the remainder of the sandy horizons are light grey to

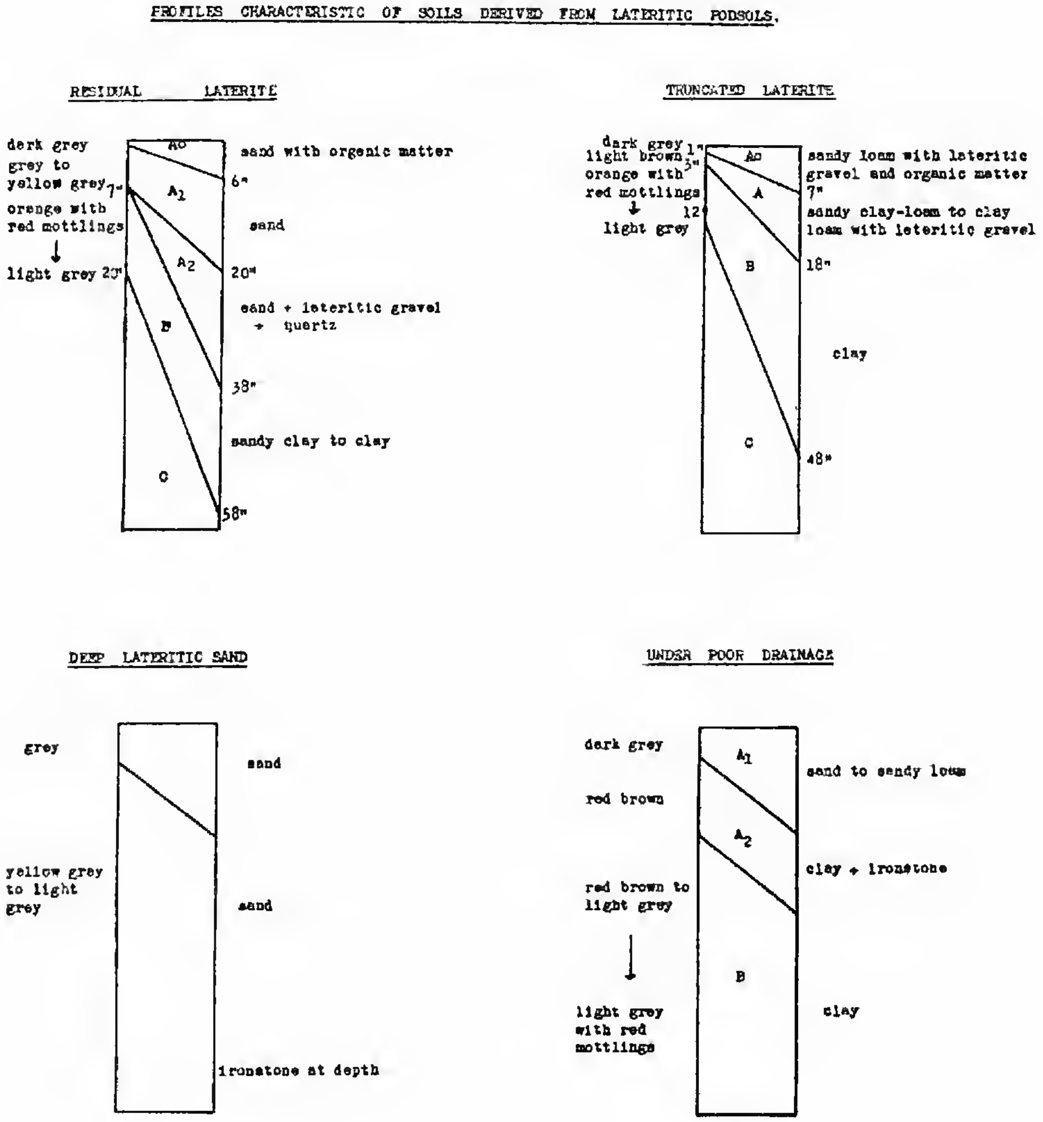


Fig. 6
Soil profiles characteristic of soils derived from lateritic podsols.

yellow-grey. Underlying the sandy surface horizon there is a mottled yellow-brown, yellow-grey and light grey clay which may contain some ironstone gravel in the upper few inches. The light grey colour usually increases with depth.

Mechanical analyses show great variation in the coarse sand : fine sand ratio, possibly because of the movements of the A horizons as mentioned above. The results of the chemical analyses show the soils to be extremely poor in P_2O_5 and nitrogen. Much of the organic matter is in a fibrous condition and does not break down readily to available forms of nitrogen. Throughout the profile the soil is acid in reaction (see Appendix I).

2. *Truncated lateritic podsols*

These soils are similar in formation to the previous one, but there is little of the sandy A horizon present. The ironstone may be in large boulders or broken down to pisolitic gravel.

The profile consists of a brown to grey loamy surface overlying at a depth of 1 to 7 inches a yellow-brown to red-brown clay containing red mottlings. There are often large pieces of ironstone 6 to 12 inches in diameter near the surface of the soil. At about 12 inches the clay becomes mottled red-brown, yellow-brown and light-grey. The light grey colour increases with depth until, below about 2 or 3 feet, it is by far the dominant colour with only a few red-brown inclusions in it.

The results of chemical analysis show that these soils are slightly higher in nutrient status than the residual lateritic podsol. The nitrogen figure is not a true index of the available nitrogen, as most of it is present as undecomposed organic matter (see Appendix I).

3. *Deep lateritic sands of acid reaction*

Within the area of residual lateritic podsols there are several areas of deep sands containing ironstone at depth. The profile consists of a grey sand overlying a yellow-grey to light grey sand at variable depth. Near Blewett's Springs these sands are predominantly coarse, the ratio of coarse sand to fine sand being 8 or 10 to 1. The silt and clay fraction is never higher than 3-5% in the first 36 inches. The high coarse sand : fine sand ratio suggests that these sands may have been winnowed by the winds of the arid period (8). The mechanical composition is remarkably constant with depth.

These soils are the most acidic (pH 5·0-5·5) and the poorest in nutrients of all the soils in the area (see Appendix I).

4. *Lateritic podsols under swampy conditions*

In several small isolated positions within the range of distribution of the residual lateritic podsol these soils occur in flat and relatively low-lying situations. Under these circumstances they become waterlogged in winter, due to the impervious nature of the underlying clay. The profile is similar to the residual laterite podsols.

B. SOILS FORMED UNDER PRESENT ENVIRONMENTAL CONDITIONS

Where complete truncation of the lateritic profile has occurred, soils have developed on the underlying rock in recent times. These soils show a close correlation with the parent material, podsols being developed over siliceous rocks, grey-brown podsols and red-brown earths over argillaceous rocks, calcimorphic soils over calcareous rocks, and ferrimorphic soils over gneissic and schistose rocks. Climate has been responsible for the differentiation of some of the soil groups. The red-brown earth grades into the grey-brown podsol at the 25-inch isohyet, and this in turn is progressively more leached with the increase in influential rainfall until the nutrient status is so low that a definite sclerophyllous formation takes the place of the savannah formation about the 35-inch isohyet. In areas of impeded drainage deep degraded rendzinas occur. These grade into shallow rendzinas in drier conditions.

Products of denudation tend to accumulate in some valleys forming a valley complex, while a saline alluvial flat has formed near the mouth of the River Onkaparinga.

1. *Podsols*

Wherever siliceous rocks of low cation status, such as quartzites and sandstones, are exposed, podsols develop. As these rocks are very resistant to weathering, most of the area over which they occur is very rugged and bold in outline and skeletal podsols are developed (see fig. 7). However, in regions of rainfall greater than 35 inches per annum and on the tops of ridges the moisture has been sufficient to severely leach the weathered material of such low cation status, and to produce a mature podsolic profile. Typically, the mature podsol shows a sandy A horizon containing floaters overlying a B horizon of sandy clay to clay (see fig. 7). On analysis these soils were seen to be low in P_2O_5 and total nitrogen and acid in reaction (see Appendix I).

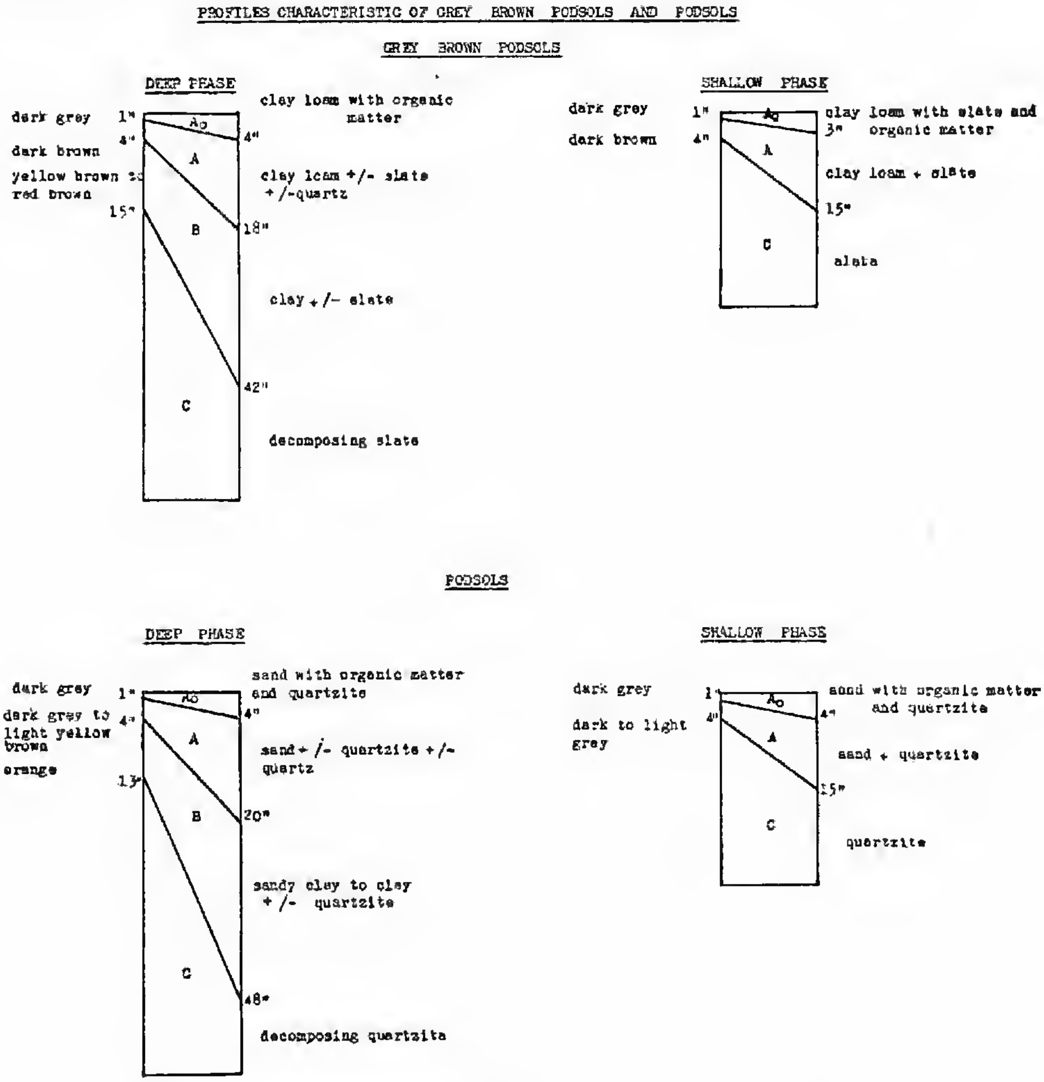

PROFILES CHARACTERISTIC OF GREY BROWN PODSOLS AND PODSOLS
GREY BROWN PODSOLS
DEEP PHASE
dark grey
dark brown
yellow brown to red brown
1"
4"
15"
A0
A
B
C
4"
18"
42"
clay loam with organic matter
clay loam +/- slate +/-quartz
clay +/- slate
decomposing slate
SHALLOW PHASE
dark grey
dark brown
1"
4"
A0
A
C
3"
15"
clay loam with slate and organic matter
clay loam + slate
slate
PODSOLS
DEEP PHASE
dark grey
dark grey to light yellow brown
orange
1"
4"
13"
A0
A
B
C
4"
20"
48"
sand with organic matter and quartzite
sand + /- quartzite +/- quartz
sandy clay to clay + /- quartzite
decomposing quartzite
SHALLOW PHASE
dark grey
dark to light grey
1"
4"
A0
A
C
4"
15"
sand with organic matter and quartzite
sand + quartzite
quartzite

Fig. 7

Soil profiles characteristic of grey-brown podsols and podsols.

However, small areas of quartzites in the Middle and Upper Adelaide Series tend to give skeletal podsols of a slightly higher nutrient status than siliceous rocks of the Lower Adelaide Series (see Appendix I), but these outcrops are apparently ecologically insignificant in their effect on the distribution of the tree stratum.

2. *Grey-brown podsols*

In that section of the area with rainfall greater than 25 inches per annum, argillaceous rocks, such as slates, phyllites and Sturtian tillite have given rise to a profile typical of a grey-brown podsol. In the mature phase this soil shows an A horizon of a clay-loam sometimes containing floaters over a clayey B horizon (see fig. 7). This mature profile is developed more extensively than in the case of a podsol (see above) because of the faster rate of weathering of the argillaceous rocks, but it is seen especially in wetter regions (rainfall greater than 30 inches per annum) and on the tops of ridges. In drier regions between 25 and 30 inches per annum weathering is probably not so rapid, as erosion is nearer equilibrium with decomposition and only an immature form of the soil is developed (see fig. 7).

Analyses show that in the drier extent of the grey-brown podsols the soil is relatively higher in P_2O_5 and total nitrogen but grades into a soil about three times lower in P_2O_5 and total nitrogen approximately along the 35-inch isohyet (see Appendix 1).

It appears that this decrease in nutrients is caused by increased leaching with increased rainfall. This is supported by the fact that the savannah formation on the relatively high nutrient status grades imperceptibly into sclerophyllous formation on the relatively low nutrient grey-brown podsols with increase in rainfall. In all cases the profile is acidic. However, the low nutrient grey-brown podsol is from three to four times higher in nutrient status than the podsol.

As would be expected in sedimentary rocks, variations occur within the slate, some tending to be more siliceous in composition than others. These slates consequently give rise to a profile sandier than that described above.

3. *Calcimorphic soils*

The main area on which these soils are developed lies between the coast and the Ochre Cove Fault scarp. Thick beds of Miocene marine limestone occur in the southern half of this fault block, while cappings of travertine limestone have overlain the Adelaide Series in the northern half, and Miocene limestone in the southern half of the fault block. On these limestones and other limestone outcrops of the Adelaide Series alkaline calcimorphic soils have developed.

The travertine limestone probably had a loessal origin during the arid Pleistocene to Recent Periods as proposed by Crocker (8). With faulting in the Pliocene to Pleistocene, dissection of the original peneplain would occur, producing valleys and completely eroding most of the lateritic profile formed in the Pliocene. Later in the arid period loessal matter would be deposited over the soil of the whole area and leached to varying degrees, depending on the influential rainfall pattern. We can assume that, in the Adelaide Hills, the pattern of annual rainfall must have been much the same as at present (see fig. 1), but of course lower in amount.

Consequently the calcium carbonate was entirely leached out in the higher rainfall regions, either then or under the present climate. However, in the more arid region—now indicated by a rainfall less than 25 inches per annum—the calcareous matter was leached down to the underlying rock and there deposited as travertine. This travertine would be formed over the whole topography but subsequent erosion, especially in the present moister climate, has worn it away greatly on the slopes and completely in the valleys where the underlying rock is exposed. Of course, it cannot be dismissed that the calcareous slates and quartzite might have added to the travertine, but it is too widespread over non-calcareous rocks, especially near Tapley's Hill, for this to account entirely for its origin. One would expect to find travertine overlying laterite in some places. But, as yet, the only indications are the presence of ironstone within the travertine on Shepherd's Hill and around the degraded rendzina on O'Halloran Hill (Sprigg 17). This laterite may be detrital lumps from higher altitudes. Stephens has also noticed a buried lateritic profile about a mile north of Christie's Beach (private communication).

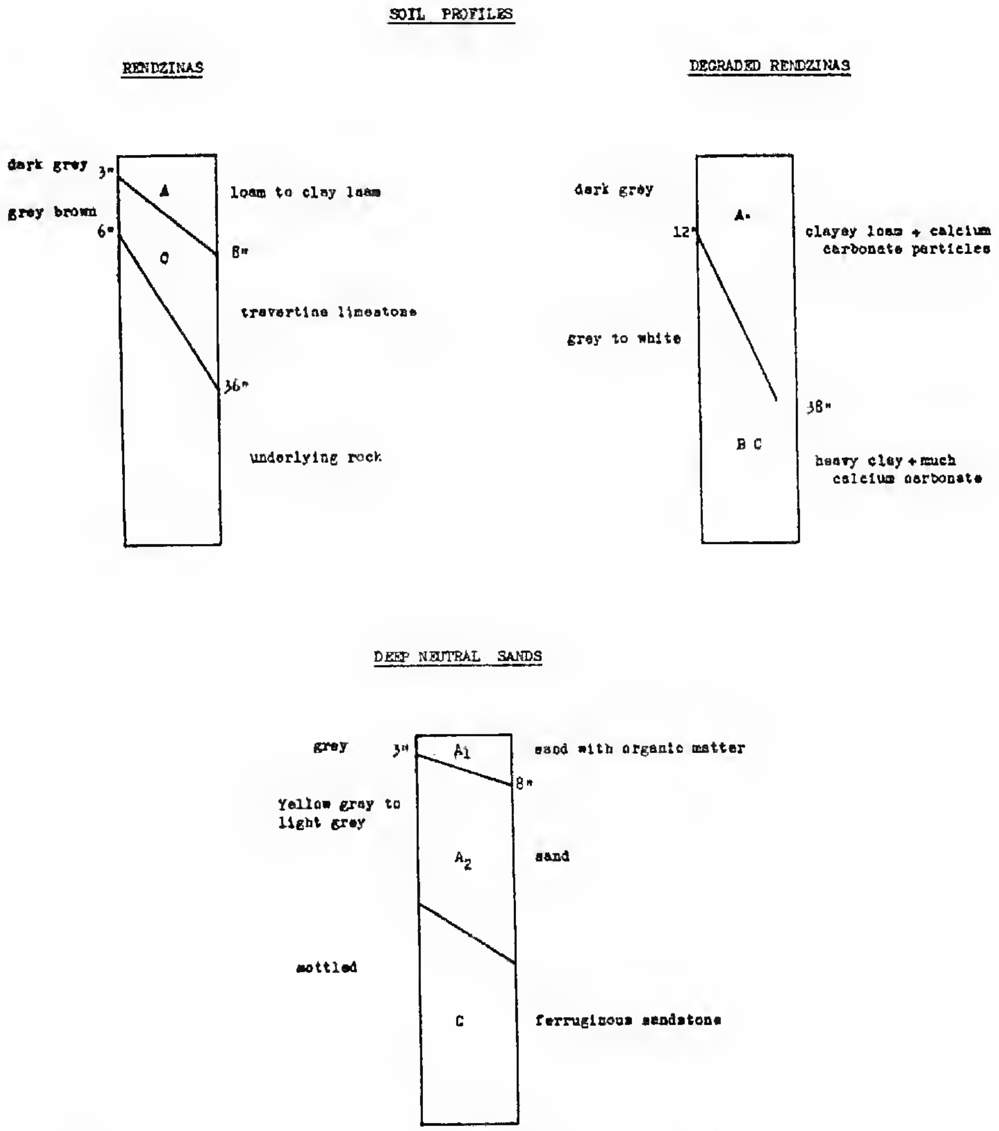


Fig. 8

Soil profiles characteristic of rendzinas, degraded rendzinas and deep neutral sands.

Over most of the travertine a dark greyish-brown loam has developed which shows very little differentiation into horizons. The depth of the soil may vary from 3 to 15 inches, but in many places the travertine is visible above the surface (fig. 8). The soils are well supplied with organic matter and have a fairly high nutrient status. These soils—rendzinas— have been cleared of vegetation and the land used extensively for cereal growing and vineyards.

Interspersed with the rendzinas near Reynella are small areas of red soil of lighter texture, which resemble terra rossas. Soils allied to terra rossas have developed on the Torrens and Beaumont limestone outcrops in the northern half of the area, where they grade into the acid grey-brown podsols.

Under conditions of retarded drainage the limestone has undergone extreme decomposition, producing a deep degraded rendzina of heavy texture (fig. 8). There is a narrow fringe of these deep black soils at the boundary between the shallow rendzina soils and the grey-brown podsols.

Along the Eden Fault scarp these calcimorphic soils grade into the red-brown earths of the Adelaide Plains, while to the east of their extent they grade into soils allied to red-brown earths developed over slates.

4. *Red-brown earths*

This soil is developed on the Adelaide Plains where the rainfall is less than 25 inches per annum, and appears to grade imperceptibly into grey-brown podsols along the Eden Fault scarp and into the calcimorphic soils in the south-west corner of the Plain. As no survey or analyses have been made over this area, the reader is referred to Piper (13) who gives a detailed description and analysis of the profile developed at the Waite Institute (the Belalie loam). In general the soil is relatively high in P_2O_5 and nitrogen and becomes alkaline in the B horizon, due to accumulation of calcium carbonate.

It is possible that the calcium carbonate in the profile is of the same loessal origin as that proposed by Crocker to explain the origin of the mallee soils (8), the loess being deposited over the deep detrital soils of the Plain during the arid Pleistocene to Recent Periods and subsequently leached, especially in the moister present climate, to form the red-brown earth profile. The degree of leaching, especially of the calcium carbonate, depends to a large extent on the rainfall, for at about the 25-inch isohyet there is a transition to allied grey-brown podsols which have no trace of calcium carbonate in the profile.

5. *Ferrimorphic soils* (?)

As these soils are of limited extent to the east of Mount Lofty Summit and along the Torrens Gorge, little data is available. They are developed on schistose and gneissic rocks of the Barossian Complex and appear to be lacking in profile development. Superficially they are similar to the shallow form of the grey-brown podsol and in some cases are indistinguishable from it. From the sclerophyllous nature of the undershrubs, they are apparently low in nutrient status. As large areas of these soils occur to the north of the Torrens Gorge a more complete examination of these soils will be made by one of us in a subsequent paper.

6. *Deep sands with neutral reaction*

These soils are of limited occurrence and occur mainly near Noarlunga and Hackham. The soil consists of a grey surface horizon containing some organic matter overlying a yellow-red or a yellow-grey sand at 3 to 8 inches. The underlying C horizon is a mottled light grey, yellow and red ferruginous sandstone (see fig. 8). The soil is slightly alkaline throughout and has a poor nutrient status. The coarse sand figure is very high, which suggests that the sand from which the underlying sandstone was formed had been winnowed.

7. *Miscellaneous soils*

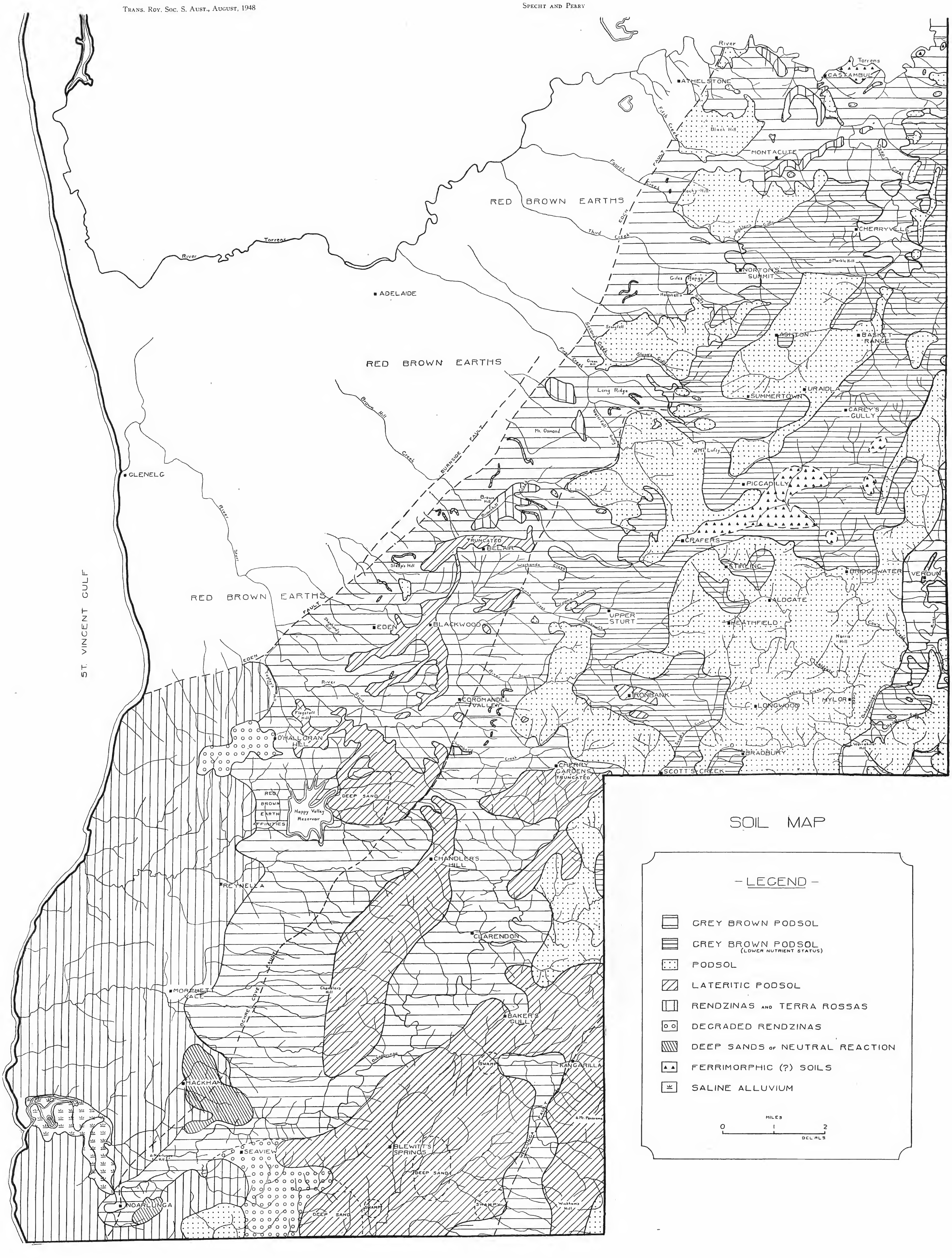
Several other soils in addition to those described above occur only in small areas.

(1) Along the drainage lines which have cut into the Willunga Fault Scarp near Kangarilla there is a soil which is waterlogged throughout the year. The profile consists of two inches of grey sand containing organic matter overlying a light grey clay, which is particularly heavy and sticky. A sclerophyllous formation dominated by *E. leucoxylon* is developed over this soil (see Appendix I).

(2) Near Seaview a red sandy soil occurs. 18 inches of red coarse sand overlies red clay, which becomes heavier and yellower at 24 inches (see Appendix I).

TABLE I

Formation	Community	Common Name	Rainfall Range	Soil	Remarks
Savannah woodland	*E. odorata* association	Peppermint gum	20 – 30″ p.a.	Calcimorphic soils, red-brown earths, podsols, grey-brown podsols, laterites	Controlled only by water relations within soil. North-facing aspects near 30″ isohyet; extensive below 25″
Savannah woodland	*E. leucoxylon-E. viminalis* association 1. *E. leucoxylon* type 2. *E. viminalis* type	 Blue gum Manna gum	 25 – 40″ p.a. 30 – 40″ p.a.	Truncated laterites and grey-brown podsols	Controlled by water relations and soils of high nutrient status. (a) North-facing aspects > 30″ South-facing aspects < 30″ (b) South-facing aspects and valleys in wetter parts.
Savannah woodland	*E. camaldulensis* association	Red gum	20 – 35″ p.a.	Grey-brown podsols and alluvial soils	Fringes watercourses below 27″; extends above 27″.
Sclerophyll scrub	*Casuarina stricta* association	Sheoak	20 – 35″ p.a.	Deep siliceous sand of neutral reaction or steep skeletal slopes	Very low water requirements
	Stringybark edaphic complex				
Sclerophyll woodland	1. *E. fasciculosa* association	Pink gum	22 – 30″ p.a.	Medium to low nutrient status Podsols and laterites especially deeper residual laterites	Low water requirements. Rare trees of *E. leucoxylon*
Sclerophyll Scrub to woodland	2. *E. Baxteri-E. cosmophylla* association	Brown stringybark-scrub gum	35 – 40″ p.a.	Podsols and laterites	Sunny aspects of ridges
Sclerophyll forest	3. *E. Baxteri-E. obliqua* association	Stringybarks	35 – 48″ p.a.	Podsols and laterites	On drier positions within this rainfall range
Sclerophyll forest	4. *E. obliqua* association	Stringybark	35 – 48″ p.a.	Highly leached grey-brown podsols	On soil of better nutrient status and water relations than *E. obliqua-E. Baxteri* associations
Sclerophyll forest	5. *E. rubida* association 6. Types and ecotones between these associations	Candlebark gum	35 – 48″ p.a.	Highly leached grey-brown podsols and alluvial soils	Watercourses from 35 – 45″; extends above 45″.
Sclerophyll and savannah woodlands	*E. odorata-E. leucoxylon-E. fasciculosa* ecotone 1. *E. odorata-E. leucoxylon* sclerophyll 2. *E. odorata* sclerophyll 3. *E. leucoxylon* sclerophyll 4. *E. viminalis* sclerophyll 5. *E. odorata-E. leucoxylon* savannah		25 – 30″ p.a.	Sclerophyll woodland on laterite Savannah woodland on grey-brown podsol	Ecotone between *E. odorata* association, *E. leucoxylon-E. viminalis* association and *E. fasciculosa* association


SOIL MAP
- LEGEND -
▭ GREY BROWN PODSOL
▤ GREY BROWN PODSOL (LOWER NUTRIENT STATUS)
⁚ PODSOL
▨ LATERITIC PODSOL
▥ RENDZINAS AND TERRA ROSSAS
o o DEGRADED RENDZINAS
▧ DEEP SANDS OF NEUTRAL REACTION
▲▲ FERRIMORPHIC (?) SOILS
⊻ SALINE ALLUVIUM
MILES
0 1 2
DEL. ALS
ST. VINCENT GULF
RED BROWN EARTHS
RED BROWN EARTHS
RED BROWN EARTHS
RED BROWN EARTH AFFINITIES
River Torrens
ATHELSTONE
CASTAMBUL
Torrens
River
Black Hill
MONTACUTE
Fifth Creek
Fourth Creek
Rocky Hill
Third Creek
Deep Creek
CHERRYVILLE
Marble Hill
NORTON'S SUMMIT
Giles Range
Horsnell's
ADELAIDE
Second Creek
First Creek
Stonyfell
Green Hill
Slapes Gully
ASHTON
BASKET RANGE
URAIDLA
SUMMERTOWN
CAREY'S GULLY
Long Ridge
Waterfall Gully
Mt. Osmond
Mt. Lofty
Brown Hill Creek
BURNSIDE FAULT
PICCADILLY
GLENELG
River Sturt
Brown Hill
CRAFERS
TRUNCATED
BELAIR
Sleep's Hill
Workanda Creek
STIRLING
BRIDGEWATER
VERDUN
ALDGATE
EDEN FAULT
EDEN
BLACKWOOD
UPPER STURT
HEATHFIELD
Norris Hill
Cox's Creek
River Sturt
CORAMANDEL VALLEY
IRONBANK
LONGWOOD
MYLOR
Flagstaff Hill
O'HALLORAN HILL
Chambers Creek
CHERRY GARDENS
TRUNCATED
BRADBURY
SCOTT'S CREEK
Happy Valley Reservoir
DEEP SAND
CHANDLERS HILL
REYNELLA
CLARENDON
MORPHETT VALE
Chandlers Hill
OCHRE COVE FAULT
BAKER'S GULLY
Onkaparinga
SWAMP
KANGARILLA
HACKHAM
Mt. Panorama
BLEWITT'S SPRINGS
SEAVIEW
DEEP SAND
WILLUNGA FAULT
O'Neill's Hill
SWAMP
SWAMP
Wickhams Hill
DEEP SAND
NOARLUNGA

(3) Saline alluvial flats have been developed near the mouth of the Onkaparinga River. These consist mainly of variable Recent alluvium containing shells. Parts are subject to flooding on exceptionally high tides, as there is no part of the flats higher than 10 feet above sea level.

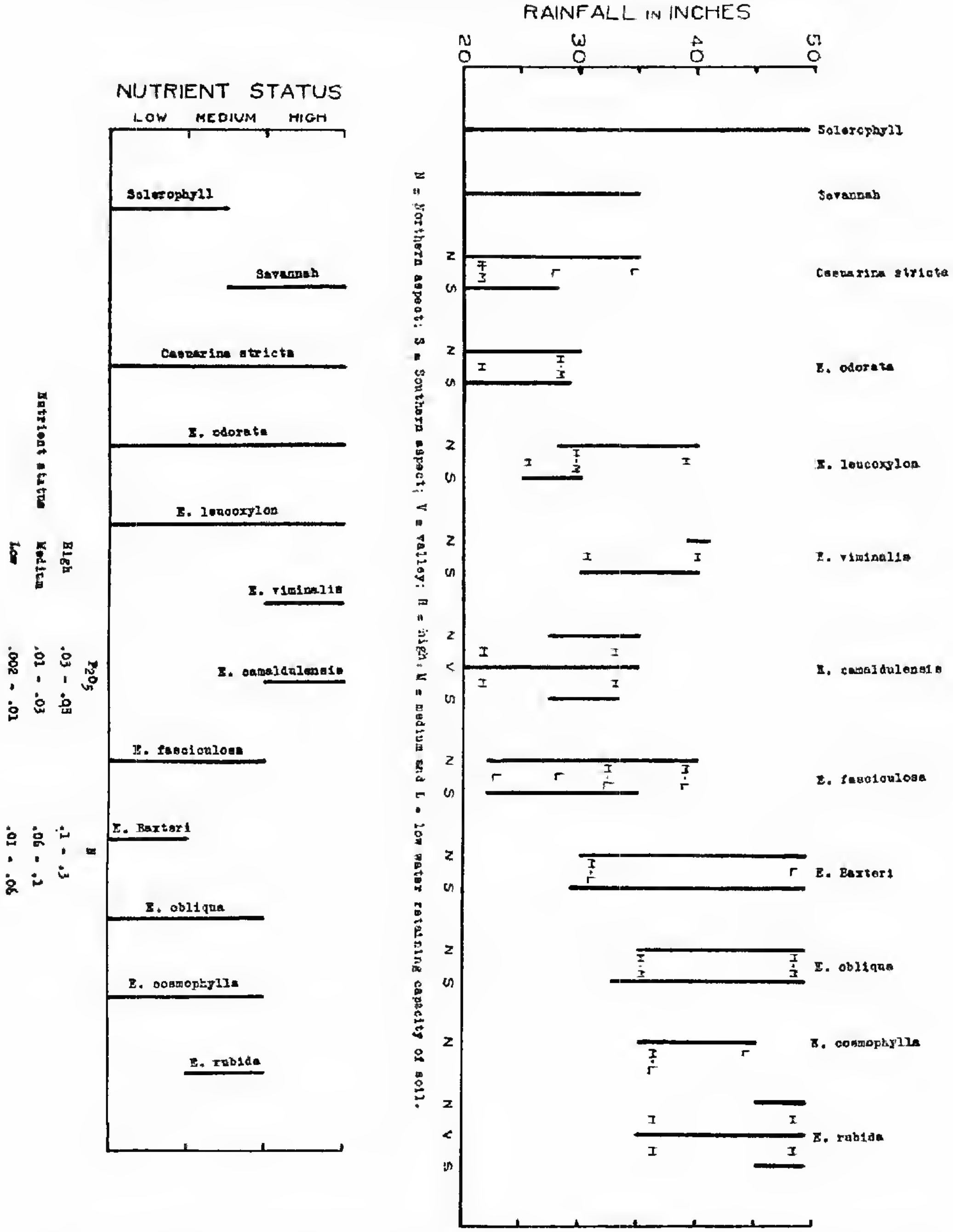


Fig. 9

Diagram showing the relationship of the dominant Eucalypt species with rainfall and nutrient status of the soils.

THE VEGETATION

It was found on reconnaissance that numerous changes in the species composition of the vegetation occur over a very small area. Consequently it was deemed advisable that the autecology of individual species should be investigated. A summary of the results obtained is shown in fig. 9, 10 and 11. Following the discussion on the environmental range of the species, there is an endeavour to group the species into logical communities, but of course any attempt is largely artificial and only for convenience. The nomenclature of the species follows that of Black (3) and Blakely (4).

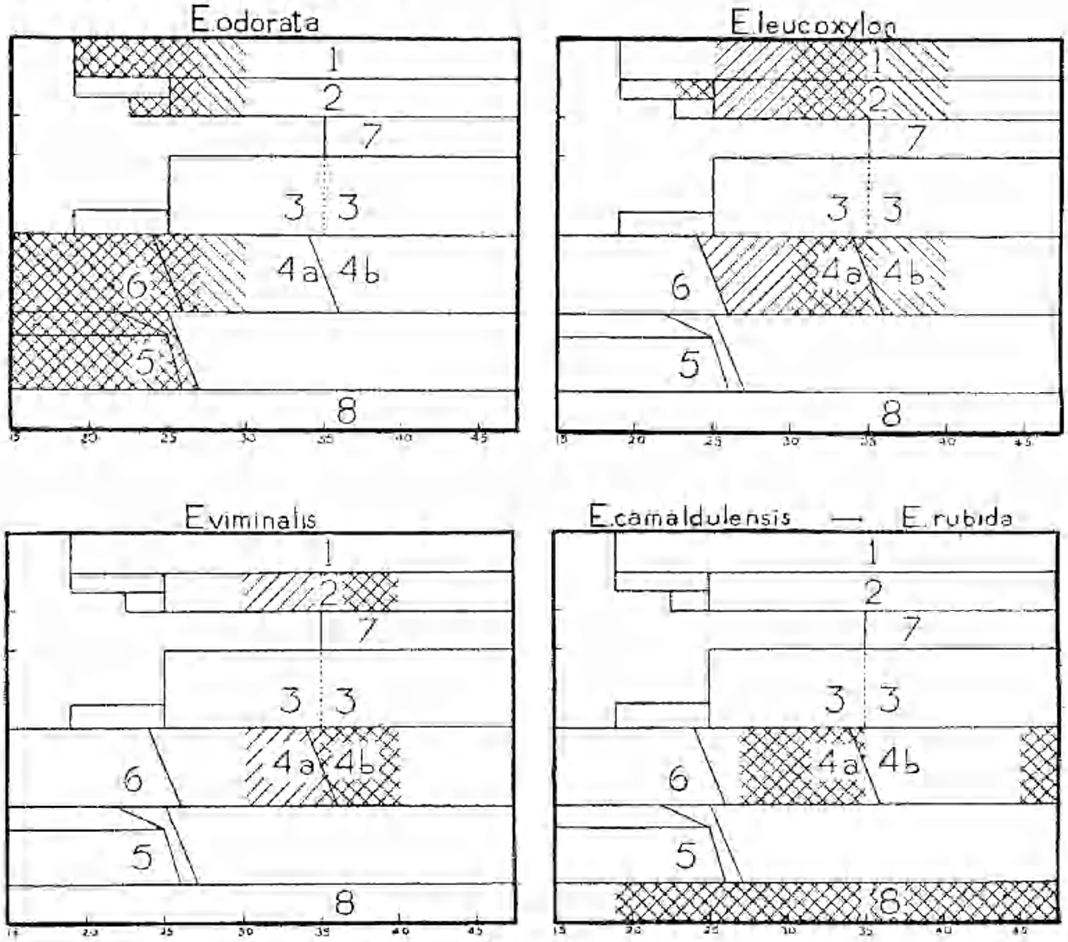


Fig 10

Diagram illustrating the distribution of various species of *Eucalyptus* in relation to soils and rainfall. The numbers on the figures refer to soils named in Figure 5.
Hatching from right to left (downwards) indicates presence on South-facing aspects only.
Hatching from left to right (downwards) indicates presence on North-facing aspects only.
Cross-hatching indicates presence on both aspects.

A. ENVIRONMENTAL RANGE

1A. *Eucalyptus odorata* (peppermint gum)

This species warrants further investigation in regard to its acceptance as a genotype, for, especially in its eastern limit, the peppermint gums exhibit a large variation in characteristic features. R. G. Brett (private communication) suggests that the species is actually a hybrid polymorph between *Eucalyptus odorata, Eucalyptus fasciculosa,* and possibly a mallee with *E. odorata* the dominant member of the cross. However as all peppermint gums, which show the same wide range in morphology, agree with Blakely's broad description of *E. odorata,* his description is accepted in this report.

E. odorata occurs within the drier part of the area, the 30-inch isohyet forming approximately the upper limit of the species, while the coast forms a barrier to it reaching the lower limit of its potential range. The species appears to be uninfluenced by the texture, the pH, or the nutrient status of the soil, for it flourishes equally well on red-brown earths, grey-brown podsols, podsols, residual and truncated laterites, and over the calcimorphic soils which occur within this rainfall range. It has been noted that towards the wetter limit of its distribution there is a marked tendency for the species to occur on the drier northern aspect only. Towards its drier limit the species is confined to soils of relatively high water-retaining capacity such as calcimorphic soils and red-brown earths, but as the rainfall increases, the species can spread over truncated laterites or residual laterites with a shallow A horizon, both of which though low in nutrient status have a clay horizon near the surface. However, the peppermint gums never occur on the deeper lateritic sands nor on the skeletal podsols developed over the thick quartzite of the Adelaide Series. These soils have a relatively low water-retaining capacity. These facts indicate that it is the moisture relations within the soil which are the major controlling factors in its distribution. This is illustrated in fig. 10.

The potential range of the species in this area is far wider than that found in other parts of the State, for Crocker (7), Jessup (11) and Piper (13) have shown that the species is restricted, in the areas which they studied, to red-brown earths (sometimes becoming slightly podsolised) within rainfall limits of 15 to 25 inches per annum. On Eyre Peninsula (7), where the maximum rainfall is only 24 inches per annum, the species is restricted to the red-brown earths between 18 and 20 inches per annum, although podsols and residual podsols occur contiguous to it.

Jessup (11) also deals with the drier limits (15 inches per annum) of the distribution of *E. odorata* on the eastern side of the Mount Lofty Ranges. Around Bordertown, in the Upper South-East, the species flourishes on calcimorphic soils with a rainfall of 20 inches per annum. Hence it appears that in the drier limit of its range *E. odorata* is mainly confined to alkaline soils of clayey nature, which have a high water-retaining capacity, whereas a wider range in regard to soils occurs towards its wetter limit, provided the higher rainfall and the lower water-retaining capacity of these soils compensate to satisfy the water requirements of the developing *E. odorata*.

1B. "Whipstick peppermint" ecotype of *Eucalyptus odorata*

At the foot of Black Hill on a podsol developed over the Mount Lofty quartzite, two distinct areas of this "whipstick mallee" occur within the *E. fasciculosa* sclerophyll community. The tree appears to approach Blakely's description of *E. odorata* var. *angustifolia*, although many of the trees exhibit fruits of the same size as the typical *E. odorata*.

As this ecotype of *E. odorata* is of restricted occurrence it can only be noted that the soil is a podsol, low in nutrient status, and developed with a rainfall of approximately 25 inches per annum.

2. *Eucalyptus leucoxylon* (blue gum)

This species is largely controlled in its distribution by the moisture relations within the soil. It occurs within the limits of the 25-inch and 40-inch rainfall isohyets, but within this range it is markedly influenced by aspect. In the drier limits the species occurs either mixed with *E. odorata* or alone on the shady, moister, south-facing slope, but as the rainfall increases to about 30 inches per annum it occupies both slopes, while with further increase the species is confined to the warmer, drier, north-facing slope of the ridges. This phenomenon is masked in the northern half of the area where the rainfall increases rapidly along the scarp from 25 inches to 30 inches per annum within three-quarters of a mile, thus limiting *E. leucoxylon* to the north-facing slopes, whereas in the south the same increase occurs gradually over two miles. Within this range occur grey-brown podsols with relatively high nutrient status, and residual and truncated laterites of relatively low nutrient status. However, although these soils differ in nutrient status, their water-retaining capacities, apart from the shallow sandy horizon of the residual laterite, would be of the same order. The fact that water relations play a large part in controlling the species distribution is further substantiated by the appearance of *E. leucoxylon* on residual laterites in the fringing community around the deeper lateritic sands in the southern part of the area. Here *E. fasciculosa* is distributed over the deep sands of the ridges with *E. leucoxylon* occupying an area, often only a few chains wide, on the shallower sands of the residual laterite, the clay horizon of which would tend to produce better water relations within the soil. In the wetter situations of the drainage lines and adjacent flat areas, *E. camaldulensis* takes the place of *E. leucoxylon*. *E. camaldulensis* also tends to supplant *E. leucoxylon* over the grey-brown podsols on wetter ridges along the Torrens Gorge, the Sturt River, and the River Onkaparinga. However, two exceptions to this general scheme occur.

The podsols developed on the Mount Lofty quartzite act as a barrier to the distribution of the species. Wherever podsols occur, in whatever rainfall, there is a sharp division between the blue gums on the grey-brown podsols and the "stringybark complex" on the podsols. This is rather curious, for the podsols and laterites are of approximately the same acidity and nutrient status in P_2O_5 and nitrogen. Of course, most of the podsols are of a very skeletal nature, especially in their drier limit, and possess a low water-retaining capacity. This fact may be of value, but there is no gradual transition evident from blue gum to the "stringybark complex" as there is with increase in rainfall and decrease in P_2O_5 and nitrogen with leaching on the grey-brown podsols. This data suggests that some other factor is influencing its distribution as well as moisture relationships. It may be micro-nutrient deficiency on the podsols. It may be bound up with competition between the trees of the "stringy-bark complex" and the "blue gums."

There is also a small occurrence of blue gums on deep lateritic sands near Happy Valley Reservoir which seems an exception to the general scheme of water relations. Fig. 10 shows the general relationship existing between *E. leucoxylon*, soils, and rainfall. In other parts of the State water relations seem to be a prominent controlling factor. On the eastern side of the Mount Lofty Range Jessup (11) has found blue gums occurring on red-brown earths with a rainfall as low as 15 inches per annum. It should be noted that these soils would possess a relatively high water-retaining capacity. Boomsma (5), working on the Southern Flinders Ranges, also gives evidence which indicates that water relations play a large part in the species' potential environment. He found blue gums along the watercourses where the annual rainfall was over 16 inches, on red-brown earths with an annual rainfall greater than 17 inches, and on podsols of lower water-retaining capacity with an annual rainfall greater than 21 inches for savannah and greater than 26 inches for sclerophyll formations associated with it.

3. *Eucalyptus viminalis* (manna gum)

This species occupies the moister, south-facing aspect of the ridges with *E. leucoxylon* or *E. camaldulensis* occupying the northern aspect between the 30- and 40-inch isohyets (see above). In higher rainfall areas it tends to occur along watercourses. The density of the trees increases with rainfall from an open woodland on the drier side to a closed forest in its wetter limit. Although this species occurs in small areas on truncated lateritic soils it is largely confined to the richer grey-brown podsols. This is probably due to higher water relationships within the grey-brown podsols. The distribution of *E. viminalis* in relation to soils and rainfall is shown in fig. 10.

4. *Eucalyptus camaldulensis* (syn. *E. rostrata*) (river red gum)

In the drier limit of the area this species is confined to the creek beds or to some distance on each side, but along the Rivers Torrens, Sturt and Onkaparinga, where the annual rainfall is greater than 27 inches, it extends over larger areas. The species is confined to grey-brown podsols on the slopes and ridges and alluvial soils in the valleys, both soils being rich in P_2O_5 and nitrogen and having high water relations. Where the redgums extend over the ridges near the rivers they tend to occupy a similar habitat to that of *E. leucoxylon* on ridges alongside minor streams. The species does not extend into areas with rainfall greater than 35 inches per annum. Its soil and rainfall requirements are summarised in fig. 10.

5. *Eucalyptus obliqua* (stringybark)

This species is a dwarf ecotype of the species growing in the eastern States, for it rarely grows higher than 80 feet.

This stringybark occurs on a wide variety of soils, such as podsols, highly leached grey-brown podsols, lateritic soils, and ferrimorphic soils (all of which are low in P_2O_5 and nitrogen), provided the annual rainfall is greater than

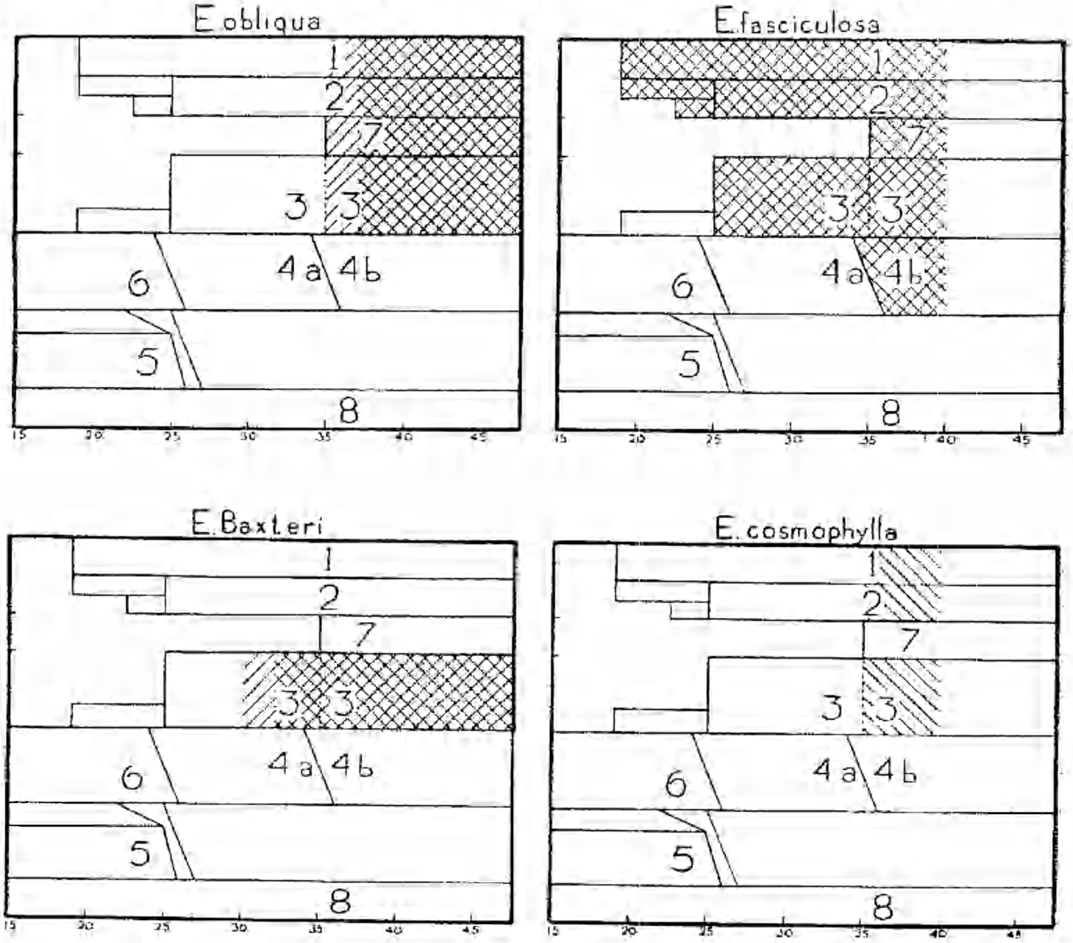


Fig. 11

Diagram illustrating the distribution of various species of *Eucalyptus* in relation to soils and rainfall. The numbers on the figures refer to soils named in Figure 5.

Hatching from right to left (downwards) indicates presence on South-facing aspects only. Hatching from left to right (downwards) indicates presence on North-facing aspects only. Cross hatching indicates presence on all aspects.

approximately 35 inches. It extends up to the maximum rainfall for the area of 48 inches per annum on Mount Lofty Summit. Aspect plays a part in its distribution towards its drier limit, for it tends to occupy the moister southern aspect. On the grey-brown podsols it tends to form either a pure community or one mixed with *E. viminalis* on the southern aspect, while a pure community of *E. leucoxylon* occurs on the northern aspect. Similarly towards the drier limit of *E. obliqua* on the podsols, *E. obliqua* tends to occur with *E. Baxteri* on the southern aspect, while *E. Baxteri* and *E. fasciculosa* occur on the northern. The soil and rainfall requirements of *E. obliqua* are illustrated in fig. 11.

If we remember that a large percentage of the rainfall is lost to the soil by run-off in the Adelaide Hills, the environmental ranges found by Crocker on the low undulating sand-dunes of the South-East (6), and by Baldwin and Crocker on the flat lateritic peneplain of Kangaroo Island (2) are comparable to that shown above for the Adelaide Hills. It should be noted here that on the flatter country of the other two localities the lower rainfall limit of the species may be as low as 24 inches per annum.

6. *Eucalyptus Baxteri* (brown stringybark)

This species has a restricted range of soil nutrients, occurring on only the very poor podsols, but with a wider moisture range than that of *E. obliqua* (see fig. 11). This is especially evident where the podsols developed over the thick quartzite of the Adelaide Series occur in regions with rainfall as low as 30 inches per annum such as on Black Hill, Morialta and Stonyfell Ridge. In these localities *E. Baxteri* tends to occur with *E. fasciculosa* on the moister south-facing side of the ridge towards its drier limit, while *E. fasciculosa* occupies the northern aspect alone. However, with increase in rainfall *E. Baxteri* soon occupies both aspects, while *E. obliqua* occurs with it at first on only the southern aspect but eventually at about the 35-inch isohyet on both aspects. As the rainfall increases still further *E. Baxteri* tends to be more prevalent on the skeletal quartzites than *E. obliqua*, and where the podsols are better developed there is a tendency for *E. Baxteri* to occur on only the drier aspects.

However, although the environment appears to be suited for its growth, no specimen of *E. Baxteri* was found on the podsol on Acklands Hill. Taylor and O'Donnell (21) have noted *E. Baxteri* occurring on truncated laterite in the Hundred of Kuitpo, and the authors have noted similar occurrences further down the Fleurieu Peninsula. Considering these occurrences, it at first seems rather surprising that *E. Baxteri* is not found on the lateritic soils of the area, but on closer examination it is seen that these soils are mainly in regions with annual rainfall less than 35 inches, and this wetter limit is near the apparently anomalous area on Ackland's Hill.

Taking into consideration the effect of differences of topography on moisture relations within the soil between the Adelaide Hills, Kangaroo Island (lower rainfall limit approximately 20 inches per annum) and the South-East (lower limit about 22 inches per annum), the environmental range of *E. Baxteri* is similar in the three habitats, that is, the species is restricted to soils very low in P_2O_5 and nitrogen such as podsols and laterites, and with a lower range of moisture relations than *E. obliqua*.

E. *Eucalyptus fasciculosa* (pink gum)

This species occupies the driest position in the "stringybark complex", occurring in areas with rainfoll as low as 22 inches per annum and extending up to 40 inches per annum. In all the localities where this species has been found the soil is acidic and low in P_2O_5 and nitrogen, but the texture of the soils (all phases of laterite podsols, highly leached grey-brown podsols and ferrimorphic soils), varies considerably.

In its drier limit the species is confined to podsols and residual laterites with a deep sandy A horizon or deep lateritic sands, the species maintaining its position only by the fact that these soils have a very low water-retaining capacity. When the A horizon becomes shallower, the water relations of the soil for the same climate improve, and *E. fasciculosa* gives way to *E. leucoxylon*. As most of the country where it occurs is gently undulating, aspect here plays little part.

In the drier limit of its distribution on the podsol of Black Hill, Rocky Hill and Stonyfell Ridge the species occurs pure on steep, skeletal, quartzite slopes on all aspects. As the rainfall increases *E. Baxteri* appears mixed with it on the southern aspect with pink gum pure on the northern aspect, and with further rainfall increases *E. Baxteri* occurs with it on both aspects. At about 35 inches per annum, as mentioned above, *E. obliqua* appears and the pink gum tends to be confined to the drier aspects, the size of the area it occupies becoming progressively smaller until only a few scattered trees occasionally occur within the "stringybark complex" at about the 40-inch isohyet. The fact that the 40-inch isohyet is approximately the species' upper limit explains its absence on soils of low nutrient status between Stonyfell Ridge and National Park. The soil and rainfall requirements of *E. fasciculosa* are illustrated in fig. 11.

As this species occupies only small areas in the broad survey carried out by Crocker in the South-East (6) little comparison can be made. One author (Specht) however, has noted on the leached sands of the South-East, that as the rainfall decreases *E. fasciculosa* tends to become more prevalent and to supplant *E. Baxteri*. On the eastern side of the Mount Lofty Ranges Jessup (11) has shown that the species occurs over relatively rich red-brown earths in a rainfall as low as 15 inches per annum. This seems anomalous compared with the environmental range found on the western side.

8. *E. cosmophylla* (scrub or cup gum)

E. cosmophylla occurs in limited areas throughout the "stringybark complex" with rainfall between 35 inches and 45 inches per annum, principally on podsolic and lateritic soils and always on the sunny aspects of the ridges (see fig. 11). A pure community occurs on a steep north-facing quartzite slope in Waterfall Gully and in the Brownhill Creek watershed. The species tends to be limited in extent because of competition with other taller Eucalypts which obstruct the sunlight. Thus *E. cosmophylla* tends to develop on very skeletal soils where the scarcity of soil restricts the number of other Eucalyptus species developing. The fact that the direct effect of insolation is a marked controlling factor is supported by the occurrence of scrub gum on only the sunny aspects, no matter what the rainfall. Taking into account the difference in topography this environmental range corresponds to that found on Kangaroo Island by Baldwin and Crocker (2). On Kangaroo Island the direct effect of isolation does not apply, for the area is a lateritic peneplain.

9. *Eucalyptus rubida* (candle-bark or white gum)

This species occupies a considerable area around gully heads on highly leached grey-brown podsols with a rainfall greater than 45 inches per annum. As the annual rainfall decreases to 35 inches the species is confined to a narrow belt of wet alluvial soil along the larger creeks. Its distribution in relation to soil and rainfall is illustrated in fig. 10.

10. *Eucalyptus elaeophora* (bastard box)

As this species only makes its appearance in the extreme north of the area no attempt has been made to determine its environmental range. This will be dealt with in a later paper. In this area the bastard box occurs on podsols and ferrimorphic soils of low nutrient status.

11. *Casuarina stricta* (drooping sheoak)

This species occurs scattered amongst *E. odorata* and *E. leucoxylon* on various soils from the coast to about the 35-inch isohyet. On very steep cliffs such as occur in the Torrens Gorge, Morialta, Slape's Gully, near the first waterfall in Waterfall Gully, the Sturt and Onkaparinga gorges, pure communities may be developed on either aspect. The sheoak occurs with *Banksia* near Noarlunga and Hackham on deep siliceous sands of neutral reaction and of low water-retaining capacity with a rainfall 20 to 22 inches. From this evidence it appears that *Casuarina stricta* can exist in much drier habitats than *E. odorata*, which often occurs in contiguous habitats which are less steep or, as in the case of the deep sands, of higher water-retaining capacity. This evidence is supported by the occurrence of *Casuarina stricta* on shallow gneissic soils along the dry Palmer scarp on the east of the Mount Lofty Ranges, with a rainfall of 20 inches per annum. This stand extends to the south, where it occurs on very shallow red-brown earths (with terra rossa affinities) around Lake Alexandrina (Jessup 11). Here the rainfall is about 15 inches per annum. On Eyre Peninsula Crocker (7) has found the species occurring over calcimorphic soils and skeletal gneissic soils from 14 to 22 inches per annum.

Crocker (6) has also found *Casuarina stricta* associated with sandy terra rossas in the South-East, where the rainfall is as high as 28 inches per annum. These observations suggest that *Casuarina stricta* can exist over a wide range of soils in respect of reaction, nutrient status and texture, but appears to be limited to those conditions in which the compensating moisture relations are low.

12. *Hybrids*

Hybrids between different species of Eucalyptus have been found especially at the junction of the distribution of two species. These hybrids possess characters intermediate between the two parent species, making identification of some trees difficult. Such a case occurs between *E. viminalis* and *E. camaldulensis* giving rise to trees with anomalous *E. viminalis* fruits, and between *E. viminalis* and *E. rubida*, thus forming stands of trees which gradually grade from one species into another.

Hybrids also occur between *E. viminalis* and *E. leucoxylon*, *E. obliqua* and *E. Baxteri*, *E. odorata* and *E. leucoxylon*, and *E. camaldulensis* and *E. leucoxylon*.

13. *Formations*

As is the case of the species of the first stratum, the undershrubs exist over a definite environmental range, some being ecological wides, others having a limited range. In general there are two definite formations—the savannah woodland formation being developed over soils rich in P_2O_5 and nitrogen, such as red-brown earths, calcimorphic soils and the slightly leached grey-brown podsols, while a sclerophyllous formation occurs on more heavily leached grey-brown podsols, podsols, laterites and ferrimorphic soils which are lower in P_2O_5 and nitrogen. On the grey-brown podsols a transition between savannah and sclerophyll occurs. This is probably connected with increased leaching with increased rainfall. However, an abrupt change occurs at the junction between richer soils and podsols. Within the formations, variation within the under-

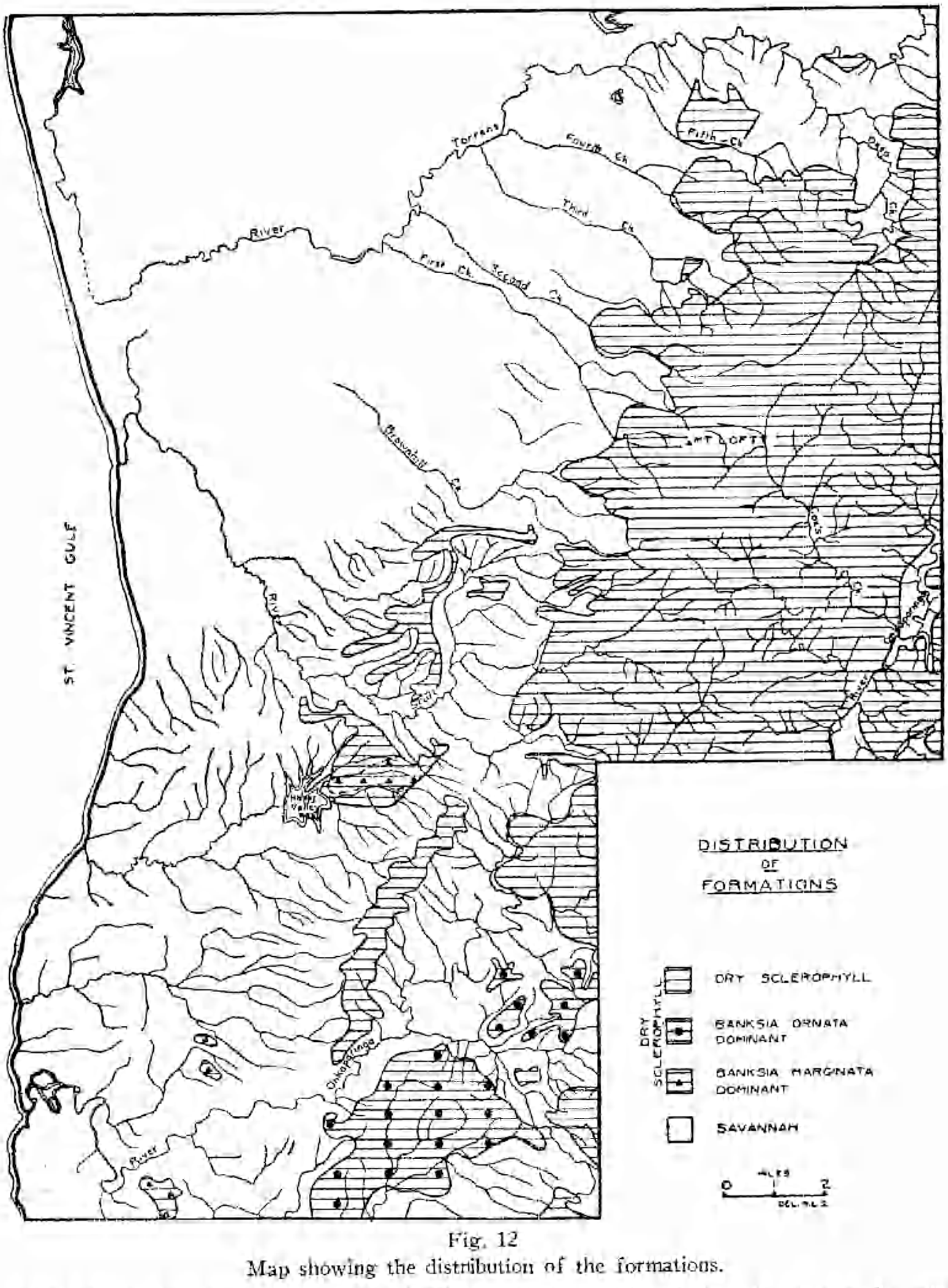


Fig. 12
Map showing the distribution of the formations.

shrubs occurs with every microhabitat, some species being dominant in one locality, others in another, but throughout the formation the same composition usually occurs. *Conospermum patens* and *Hypolaena fastigiata* are restricted to the residual laterite on the Eden-Moana fault block, while *Banksia ornata* appears on the deep lateritic sands on the Ochre Cover fault block. In all cases the formations are developed independently of the dominant trees.

Some characteristic species (*e.g., Hibbertia acicularis, Olearia ramulosa,* etc.) are ecological wides and occur throughout the savannah and sclerophyll, but extreme splitting would come into ecological classification if these species were taken into account. Further investigation, however, is warranted into the autecology of individual species of the lower strata.

The distribution of the formations is indicated in fig. 12 and in pl. VI.

B. CLASSIFICATION OF THE PLANT COMMUNITIES

In classifying plant communities the authors have adhered as closely as possible to the scheme proposed by Wood (9). An association is defined as any natural group of species occurring in similar habitats. When there is a modification of only the dominant tree stratum of an association by a small change in environment, these stands are called vegetation types of the association. If, however, the associated undershrubs change with the microhabitat over a small area while the tree stratum of the association remains the same, these stands are termed societies of the association. The term community is used for any assemblage of plants. All the communities appear to be climax communities, the only communities showing seral relationships occurring in the swamps and sandhills or as stages in the regeneration of forests after clearing and burning.

The vegetation has been classified into nine associations, the relationships and environments of which are summarised in Table I.

1. *Eucalyptus odorata* association (see pl. VIII, fig. 3)

Within the rainfall limit of 30 inches per annum a pure association of *E. odorata* savannah woodland occurs over red-brown earths, calcimorphic soils, and grey-brown podsols. Over all this area *E. odorata* grows to a small tree less than 30 feet in height or may assume a "mallee" habit. Associated with it and sometimes codominant are *Melaleuca pubescens* (on the calcimorphic soils) and *Casuarina stricta,* both of which are small trees. *Acacia pycnantha* also forms a distinct second stratum with grasses such as *Danthonia* spp., *Stipa* spp. and *Themeda australis,* usually constituting the ground stratum. However, the savannah woodland has been invaded by a large number of introduced plants, which in many cases alter the facies of the association, *e.g.,* olive (*Olea europaea*), hawthorn (*Crataegus monogyna*) or dog rose (*Rosa canina*), but usually the facies is little changed, for even though the invaders are numerous they are small.

The land on which this association occurs is some of the best in the area. Much of it has been cleared and is now being used for cereal growing, vineyards and grazing.

A floristic list is given in Appendix II.

2. *Eucalyptus leucoxylon – Eucalyptus viminalis* association

This association lies between the 30 and 35-inch isohyets on grey-brown podsols and truncated laterites, *E. leucoxylon* occupying the drier northern aspect of the ridges between the 30- and 35-inch isohyets, with *E. viminalis* on the moister southern aspects. The undershrubs are essentially the same as in the *E. odorata* association, with *Hibbertia acicularis* and *Olearia ramulosa* more prevalent. The undershrubs show no variation at all with aspect. Hence as these two *Eucalyptus* species tend to occur mixed on the tops of the ridges and further south, it is best to look upon these pure stands with similar undershrubs, as *E. leucoxylon* and *E. viminalis* woodland types differentiated by microhabitats within the *E. leucoxylon – E. viminalis* association.

Between the 25- and 30-inch isohyets *E. leucoxylon* occupies the moister southern aspect either alone or mixed with *E. odorata*. *E. odorata* then occurs on the drier northern aspect. These pure *E. leucoxylon* savannah woodland stands may be considered as an *E. leucoxylon* type of the above association, for it occupies a similar microhabitat. However, although the mixed savannah stand of *E. leucoxylon* and *E. odorata* occupies a similar place to the *E. leucoxylon* type, it must be considered as an ecotone between the two associations.

3. *Eucalyptus camaldulensis* association (see pl. VIII, fig. 1)

This association is well defined. As the distribution and the environmental range of *E. camaldulensis* has been discussed above, there is no need for recapitulation. Along the creek beds *Cyperus vaginatus*, together with *Juncus pallidus* and *J. polyanthemos*, are the dominant plants. Occasionally *Cytisus canariensis* and *Rubus fruticosus* have invaded the association in the wetter regions. However, away from the creeks the vegetation is of the same savannah type as occurs within the *E. leucoxylon* – *E. viminalis* association. In the watercourses amongst the lateritic sands *Leptospernum pubescens*, *Melaleuca decussata*, *Callistemon salignus*, *Acacia rhetinoides*, and *A. verniciflua* occur as well as the species mentioned above.

4. *Casuarina stricta* association (see pl. IX, fig. 4)

This association occurs in limited areas of extremely low water relationships, such as steep rocky slopes and the deep siliceous sands of neutral reaction near Noarlunga and Hackham, where the rainfall is just over 20 inches per annum. On these deep siliceous sands *Banksia marginata* and, in some places, *Callitris propinqua*, are codominant. Here the association is definitely sclerophyllous, the most important plants being *Xanthorrhoea semiplana* and *Adenanthos terminalis*. Other common shrubs are *Dodonaea viscosa*, *Bursaria spinosa*, *Olearia ramulosa*, *Exocarpus cupressiformis*, *Calythrix tetragona*, *Acacia pycnantha*, *A. armata*, *Banksia ornata*, *Hibbertia stricta*, *Grevillea lavandulacea*, and *Kennedya prostrata*. *Asclepias rotundifolia* and *Solanum sodomaeum* have invaded the area. *Scirpus nodosus* and *Lepidosperma carphoides* are fairly common, while *Muehlenbeckia adpressa*, *Carpobrotus aequilaterale*, and *Adenanthos terminalis* occupy large areas of ground. Of the herbaceous plants *Oenothera odorata* and *Salvia verbenaca* are common, while the grasses *Enneapogon nigricans*, *Themeda australe* and *Briza maxima* occur sparingly. *Loranthus Miquelii* sometimes infests *Casuarina* stricta.

On steep slopes the association approaches a sclerophyllous community, *Xanthorrhoea quadrangulata* in particular being dominant. *Exocarpus cupressiformis*, *Bursaria spinosa*, *Dodonaea viscosa*, *Olearia ramulosa*, *Banksia marginata*, *Asclepias rotundifolia* and *Osteospermum moniliferum* are often prevalent, together with ferns such as *Cheilanthes tenuifolia* and *Pleurosorus rutifolius* and the grasses *Themeda australis*, *Stipa setacea* and *Danthonia semiannularis*. *Loranthus exocarpi* occurs occasionally on *Casuarina stricta* and *Exocarpus cupressiformis*.

From the nature of the *Casuarina stricta* association it seems that it could be classed as an extremely dry association of the "stringybark edaphic complex." In some parts, however, it has closer affinities to a savannah woodland formation, while according to Wood (24) a savannah woodland formation of *Casuarina stricta* occurs on rendzinas near Port Noarlunga.

5. "*Stringybark edaphic complex*" (see pl. VIII, fig. 2, 3, 4, and IX, fig. 1, 2, 3).

On soils low in nutrient status, provided the water relations do not permit the development of *E. odorata* or *E. leucoxylon*, there occur six species of Eucalyptus (namely *E. fasciculosa*, *E. Baxteri*, *E. obliqua*, *E. cosmophylla*, *E. rubida* and *E. elaeophora*) whose environmental ranges coincide with the habitats found within this section. All of these six species are extremely sensitive to small changes in environment. As shown above, the distribution of all is controlled by the moisture relationships within the soil and the nature and/or the P_2O_5 and nitrogen level of the soil, while *E. cosmophylla* is probably controlled by insolation.

In dissected country, especially with a complex pedology such as occurs in the Adelaide Hills, a large number of micro-habitats occur every few chains. Each microhabitat is favourable for the development of a certain combination of *Eucalyptus* species and undershrubs whose autecology coincides with the conditions at that spot. Thus we have a large number of combinations of species produced, each occupying only a limited area (which is often quite small but may be up to a couple of square miles in extent).

Hence, within the area, it is possible to distinguish the combinations of Eucalyptus species which occur in similar habitats which are set out in Table II.

TABLE II

ON PODSOLS AND LATERITES

E. obliqua
E. obliqua – E. Baxteri
E. obliqua – E. Baxteri – E. fasciculosa
E. obliqua – E. Baxteri – E. cosmophylla
E. obliqua – E. Baxteri – E. cosmophylla – E. fasciculosa
E. obliqua – E. fasciculosa
E. obliqua – E. fasciculosa – E. cosmophylla
E. Baxteri – E. fasciculosa
E. Baxteri – E. fasciculosa – E. cosmophylla
E. Baxteri – E. cosmophylla
E. fasciculosa
E. cosmophylla

ON GREY-BROWN PODSOLS

E. obliqua
E. obliqua – E. fasciculosa
E. obliqua – E. rubida
E. fasciculosa – E. cosmophylla
E. fasciculosa
E. rubida

ON FERRIMORPHIC SOILS

E. elaeophora
E. elaeophora – E. fasciculosa
E. elaeophora – E. obliqua
E. obliqua

In general the undershrubs constitute a sclerophyllous community of remarkably constant composition no matter what the combination of dominant trees, although the frequency of the individual species varies with the microhabitats. However, these changes in the frequency of the species may occur within a single combination of *Eucalyptus* species as well as between combinations, thus giving little significance to the use of the undershrubs in an attempt to classify the communities under discussion.

A glance at the map of the distribution of the six *Eucalyptus* species in the area under discussion reveals the extreme difficulty of formulating a satisfactory system of classification of the combinations of these species. Considering the variability of the micro-habitats over a small area, it seems justifiable to consider areas containing these species where a more uniform habitat exists. Such a case is found on the more level topography of the lateritic peneplain of Kangaroo Island and the sand-dune ranges of the South-East. On Kangaroo Island *E. Baxteri – E. cosmophylla* sclerophyll association is present over a wide area with *E. obliqua*, *E. Baxteri* and *E. cosmophylla* occurring mixed in the wetter regions (2). In the South-East, *E. Baxteri* sclerophyll association occurs over wide areas of a uniform edaphic condition with *E. obliqua* occurring on the better soils with a rainfall greater than 24 inches per annum (6). We therefore see that under a more uniform habitat the same species (both trees and undershrubs) will be present in the same combination and frequency over a wide area and can be classified as an association. On close examination of the Adelaide Hills the *E. obliqua – E. Baxteri* association of the South-East and the *E. Baxteri* – E. cosmophylla association of Kangaroo Island are apparent over small areas where an analogous environment is present.

As *E. fasciculosa* occurs pure in large areas toward the drier limit of the complex it seems logical to class this as an association. *E. obliqua* also tends to occur pure over the highly leached grey-brown podsols. Definite areas of *E. rubida* occur along the watercourses in a rainfall of 35 to 45 inches per annum, and in larger areas on grey-brown podsols in the wetter regions. Hence we could separate an *E. obliqua* association and an *E. rubida* association, but for further evidence to support these last two associations we shall have to look to the eastern States.

It is seen that within the "stringybark edaphic complex" there are possibly at least five associations, namely:—

E. obliqua association
E. obliqua – E. Baxteri association
E. Baxteri – E. cosmophylla association
E. fasciculosa association
E. rubida association

As only the southern limit of *E. elaeophora* occurs in the area, no conclusion can be reached as yet as to its status in the "stringybark complex".

The other combinations may be regarded as forest types or ecotones of the above associations.

The dominant undershrubs of this dry sclerophyllous edaphic complex vary from place to place independently of the tree species. Usually about six species (*Acacia myrtifolia, Pultenaea daphnoides, Leptospermum scoparium, Epacris impressa, Hakea rostrata, Xanthorrhoea semiplana*) appear to be codominant, but local variations in percentage frequency occur. On the grey-brown podsols *Daviesia corymbosa* tends to become a codominant undershrub as well. On the deeper residual lateritic podsols near Blewitt's Springs with a rainfall of 25 to 30 inches per annum *Banksia ornata* becomes a codominant undershrub, while under swampy conditions *Banksia ornata* is replaced by *Callistemon* spp. Often *Pteridium aquilinum* and grasses have become dominant on the highly leached grey-brown podsols and laterites after clearing.

A floristic list is given in Appendix II.

Cytisus canariensis, Ulex europaeus and *Rubus fruticosus* have invaded the complex in places, especially along the roads.

The moist shady valleys of Waterfall Gully tend to develop a peaty swamp vegetation with dense stands of *Leptospermum pubescens, Gahnia trifida* and *Goodenia ovata,* while on the edges occasional *Utricularia dichotoma, Sprengelia incarnata* and the fern *Schisaea fistulosa* occur. It is within these swamps that specimens of *Todea barbara* occur. The swamps do not persist far down the creek but give way to moist regions which support dense mats of ferns such as *Gleichenia circinata, Blechnum capense, B. discolor, Adiantum aethiopicum* and *Pteridium aquilinum,* together with an occasional specimen of *Asplenium flabellifolium* and *Pleurosurus rutifolius.* Similar swampy creeks are found near Longwood.

In the creeks near Heathfield large quantities of *Aponogeton distachyus* (Cape pond weed) and *Lemna minor* can be found in spring.

6. *Ecotones*

(1) Ecotones, in the sense of transition zones rather than tension belts, occur between all the associations, but especially along the junction of the "Stringybark

edaphic complex" and other associations, as here we have seven Eucalypt species with overlapping environmental ranges.

(2) *E. odorata – E. leucoxylon – E. fasciculosa* ecotone. *E. leucoxylon* and *E. odorata* have overlapping environmental ranges between the 25" and 30" isohyets on both the grey-brown podsols and laterites of the Eden-Moana Fault Block. Towards the drier limit *E. leucoxylon* occupies the shady moister aspect of the ridges, whereas towards the wetter it spreads out over both aspects. *E. odorata* is here unaffected by aspect and occurs mixed with *E. leucoxylon* up to the 30" isohyet. Such stands occur on the Eden-Moana Fault Block from Happy Valley Reservoir to National Park. As shown above, the nutrient status of grey-brown podsols and laterites is different, the laterites being low whereas the grey-brown podsols are relatively high. Consequently, although the *Eucalyptus* species are not affected, the undershrubs are respectively those associated with sclerophyllous and savannah communities. On the shallow lateritic residual podsols of the Ochre Cove Fault Block an *E. leucoxylon* sclerophyllous community containing a few isolated trees of *E. fasciculosa* merges into the *E. fasciculosa* association of the "stringybark-edaphic complex" on the deeper lateritic residual podsols. This association contains an occasional tree of *E. leucoxylon*. Throughout the areas of blue gum and peppermint gum mentioned above, small areas of an *E. viminalis* sclerophyllous community occur.

The difficulty arises in classifying such stands. As the *E. leucoxylon – E. odorata* sclerophyllous community has a constant structure over a considerable area, one could look upon this as an association, with the *E. leucoxylon* sclerophyllous stand, such as occurs on the Ochre Cove Fault Block and at Happy Valley Reservoir, as a sclerophyllous woodland type within the association. However, as pointed out above, there is a marked change in the undershrubs independently of the associated trees, so that *E. leucoxylon – E. odorata* savannah and *E. leucoxylon – E. odorata sclerophyllous* woodlands occur contiguously over considerable areas. This change in the undershrubs is too vast to allow the stands to be classified as societies within the same association. The presence of patches of *E. viminalis* throughout, and occasional trees of *E. fasciculosa* in the stands on the Ochre Cove Fault Block, provides further evidence that the stands do not constitute an association. It therefore seems better to regard the stands as an ecotone between the three associations, occurring at its limits, *i.e.*, the *E. odorata* savannah woodland association, the *E. leucoxylon – E. viminalis* savannah woodland association, and the *E. fasciculosa* sclerophyll woodland association.

The species composition of the savannah stands is similar to that of the *E. odorata* association. In the sclerophyllous stands several undershrubs are codominant. On the Eden-Moana Fault Block *Banksia marginata, Adenanthos terminalis* and *Kunzea pomifera* are prevalent in the south on the deeper residual laterite whereas *Xanthorrhoea semiplana, Hakea rostrata* and *H. ulicina* are prevalent in the north on truncated laterite. A list of the species present in the sclerophyll stand is given in the appendix.

The "whipstick mallee" form of *E. odorata* on the podsol at the foot of Black Hill could possibly be classed within this ecotone.

7. *Miscellaneous communities which occupy only small areas*

(1) *Coastal Sandhill communities*

At Port Noarlunga and Christie's Beach there are small areas of sandhills on which distinct communities develop.

A. At Port Noarlunga the dominant plants are three shrubs, *Acacia longifolia, Myoporum insulare* and *Olearia axillaris,* which all grow to a height of

4 to 6 feet. The most important associated plants are *Calocephalus Brownii, Leucopogon parviflorus, Arctotis stoechadifolia, Muehlenbeckia adpressa, Cakile maritima, Carpobrotus aequilaterale, Rhagodia baccata, Suaeda australis, Spinifex hirsutus* and *Scirpus nodosus*. Others which occur much less frequently are *Dianella revoluta, Scaevola crassifolia, Kennedya prostrata, Pimelea serpyllifolia, Lotus australis, Luzula campestris* and the grass *Lagurus ovatus*. It should be noted that a large proportion of these plants are prostrate creeping plants. All the plants are stunted and dwarfed owing to the poor and saline nature of the soil and the exposed position.

B. *At Christie's Beach* there is a smaller area of dunes which are not as well stabilised as those at Port Noarlunga. The flora is not as well developed, the dominant and sometimes only plant being *Ammophila arenaria*. Other plants are infrequent, but the following do occur:—*Acacia longifolia, Olearia axillaris, Dianella revoluta* and *Euphorbia terracina*.

(2) *Coastal cliff communities*

With the exception of the two small areas of sandhills mentioned above the coastline is generally marked by cliffs, the vegetation of which, besides being extremely variable, is scattered and stunted owing to the exposed conditions and shallow soils. The chief shrubs present are *Alyxia buxifolia, Myoporum insulare, Olearia ramulosa, Beyeria Leschenaultii, Nitraria Schoberi, Acacia ligulata, A. longifolia, Eutaxia microphylla, Atriplex paludosum, Enchylaena villosa, Rhagodia baccata, Pomaderris racemosa, Melaleuca decussata*, and *Westringia rigida*. Other plants which commonly occur are *Carpobrotus aequilaterale, Scaevola microcarpa, Myoporum parvifolium, Zygophyllum Billardieri, Kennedya prostrata, Dampiera rosmarinifolia, Dianella revoluta, Cakile maritima, Oenothera odorata, Asphodelus fistulosus* and *Velleia paradoxa*.

(3) *Coastal Swamps*

Near the mouth of the Onkaparinga river there is a small area of saline swamp, some of which is subject to flooding at high tides. This small area contains the best example of succession found during the survey. The sere can be illustrated as follows:—

Arthrocnemum sp.
↓
Arthrocnemum sp. – *Salicornia* sp.
↓
Salicornia sp. – *Atriplex paludosum*
↓
Atriplex paludosum – *Nitraria Schoberi*

The direction of the arrows indicates deeper water table, decreasing salinity and less frequent flooding.

A. In the lowest areas which are subject to flooding at high tides *Arthrocnemum* sp. is the first plant to become established. The spreading habit of this plant leads to a gradual raising of the ground level due to collection of alluvial material.

B. On the slightly higher areas not subject to such frequent flooding *Salicornia* sp. becomes codominant with *Arthrocnemum*. Associated with these two plants is *Samolus repens*.

C. Where flooding is rare and only occurs at exceptionally high tides *Arthrocnemum* is not so important although still present. The dominants in this part are *Salicornia* sp. and *Atriplex paludosum*. Associated with them are *Samolus repens, Plagianthus microphyllus, Kochia oppositifolia, Frankenia pauciflora,* and *Carpobrotus aequilaterale*.

D. The highest parts of the swamp are only flooded by the infrequent freshwater floods caused by overflowing of the Onkaparinga River. A more complete vegetative cover is present. The dominants are *Nitraria Schoberi* and *Atriplex paludosum*, and associated with them are *Salicornia* sp., *Arthrocnemum* sp., *Enchylaena villosa, Suaeda australis, Rhagodia baccata, Plagianthus microphyllus, Wilsonia humilis, Carpobrotus aequilaterale, Frankenia pauciflora* and *Distichlis spicata*. *Juncus maritimus* is common in some parts.

SUMMARY

This paper deals with the ecology of portion of the Mount Lofty Ranges between the River Torrens and Noarlunga.

Working on the premise that every plant has a certain potential environment, the climate, soils and vegetation have been studied and attempts made to correlate the distribution of the dominant trees and association with the environment.

Both mechanical and chemical analyses have been made on soil samples typical of each of the soil groups present in the area, and suggestions are given as to the genesis of each soil.

To add breadth to any conclusions drawn from the data collected, the environmental range of the dominant species is discussed with reference to their environment in other parts of South Australia which have been studied by other ecologists.

ACKNOWLEDGMENTS

It would be impossible here to satisfactorily acknowledge the great assistance which has been so willingly given in this research by a large number of people. We can sincerely say that their help has been greatly appreciated. In particular we would like to express our appreciation of the help and advice which has been so readily given by Professor J. G. Wood.

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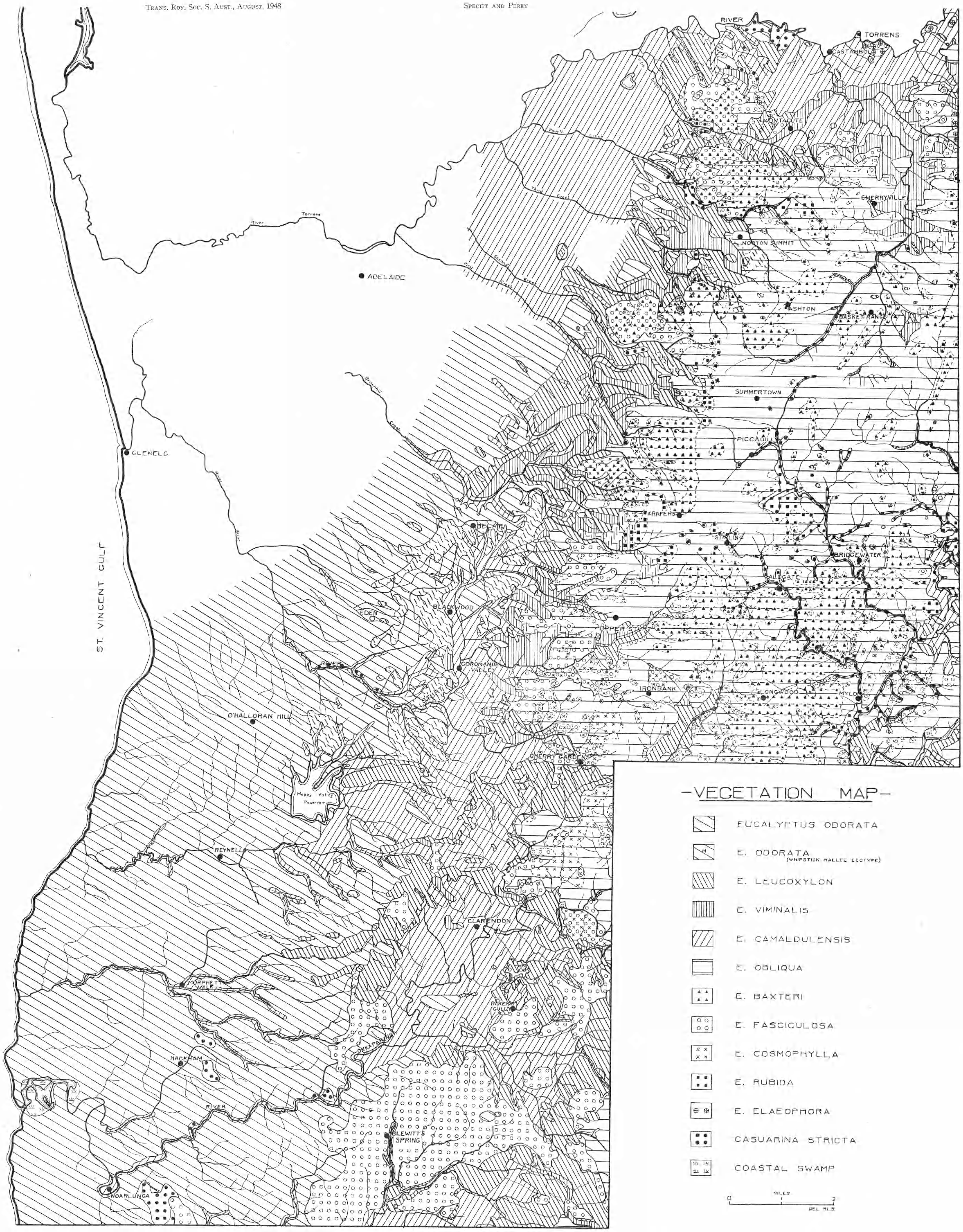
-VEGETATION MAP-
EUCALYPTUS ODORATA
E. ODORATA (WHIPSTICK MALLEE ECOTYPE)
E. LEUCOXYLON
E. VIMINALIS
E. CAMALDULENSIS
E. OBLIQUA
E. BAXTERI
E. FASCICULOSA
E. COSMOPHYLLA
E. RUBIDA
E. ELAEOPHORA
CASUARINA STRICTA
COASTAL SWAMP
MILES
0
1
2
DEL. R.L.S.
RIVER
TORRENS
CASTAMBUL
MONTACUTE
Fourth Creek
Third Creek
Second Creek
First Creek
CHERRYVILLE
NORTON SUMMIT
River Torrens
ADELAIDE
ASHTON
BASKET RANGE
SUMMERTOWN
Brownhill Creek
GLENELG
PICCADILLY
CRAFERS
Sturt River
BELAIR
STIRLING
BRIDGEWATER
ALDGATE
ST. VINCENT GULF
EDEN
BLACKWOOD
UPPER STURT
RIVER
CORAMANDEL VALLEY
IRONBANK
LONGWOOD
MYLOR
O'HALLORAN HILL
CHERRY GARDENS
Happy Valley Reservoir
REYNELLA
CLARENDON
MORPHETT VALE
BAKERS GULLY
ONKAPARINGA
HACKHAM
RIVER
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APPENDIX I

Results of mechanical and chemical analyses of soil profiles typical of soils within the area. The grid references give the localities on the Echunga and Adelaide military ordnance maps.

GREY-BROWN PODSOLS AND ALLIED SOILS

Locality	Happy Valley Reservoir			Brownhill Creek				Upper Sturt			Summertown	
Grid reference	578656			660773		670790		690730			717810	
Horizon	A	B	B	A	B	A	B	A	B	C	A	B
Depth (inches)	0–10	10–15	15–27	0–8	8–16	0–10	10–20	1–15	15–28	28–36	0–12	12–48
	%	%	%	%	%	%	%	%	%	%	%	%
Coarse sand - - -	28·0	13·0	15·7	16·8	4·0	11·1	2·0	14·2	1·8	5·2	8·3	2·1
Fine sand - - -	35·5	16·5	11·3	40·3	31·0	38·4	24·2	47·3	20·6	31·2	43·2	18·3
Silt - - - - -	12·5	8·5	8·0	26·7	21·3	23·0	17·6	21·5	27·5	29·2	30·7	17·1
Clay - - - -	24·0	62·0	64·5	16·3	43·7	27·5	56·2	17·4	50·1	34·4	17·8	62·5
Gravel - - - -	0	0	0	0	0	38	0	28	0	0	60	0
P_2O_5 - - - -	·048	—	—	·063	·052	·071	—	·021	—	—	·021	·019
Nitrogen - - - -	·114	·051	·023	·268	·086	·19	·063	·051	·024	—	·075	·038
Reaction pH - - -	*8·0	8·1	8·0	†7·5	7·6	5·2	5·2	5·3	5·4	5·4	5·9	5·6

* Allied to red-brown earths. † Near limestone.

PODSOLS

Locality	Ackland's Hill			Mt. Lofty		Mt. Lofty Summit		Noarlunga			Long Ridge*		Glen Osmond*
Grid reference	660700			710744		710795		534525			690810		658786
Horizon	A	B	C	A	B	A	B	A	A	B	A1	A2	A
Depth (inches)	1–20	20–34	34+	0–12	12–48	0–16	16–36	0–6	6–12	12–20	0–18	18+	0–12
	%	%	%	%	%	%	%	%	%	%	%	%	%
Coarse sand - -	59·0	29·6	65·5	65·2	22·8	70·4	28·7	76·0	74·0	15·5	62·8	72·6	57·0
Fine sand - -	31·0	12·5	10·4	23·8	12·2	17·8	11·3	13·0	15·0	11·0	24·8	18·8	28·8
Silt - - -	5·0	19·6	9·3	6·0	9·5	5·1	9·0	6·5	6·0	5·5	7·9	4·3	7·5
Clay - - -	29·6	38·3	14·8	5·0	55·5	6·7	51·0	4·0	5·0	68·0	4·5	4·3	6·7
Gravel - - -	53·0	0	0	27	0	44	0	0	0	0	0	0	48
P_2O_5 - - -	·0036	—	—	·0066	—	·0044	—	·0086		—	·035	—	·015
Nitrogen - -	·021	·018	—	·057	·054	·040	·042	·090	·017	—	·192	·017	·071
Reaction pH - -	6·1	5·6	4·8	6·3	5·3	5·7	5·2	6·0	6·1	5·9	6·2	5·9	5·9

* Developed over small outcrops of quartzite.

Residual Lateritic Podsols

Locality	Blackwood					Cherry Gardens				Happy Valley		
Grid reference	620690					650640				579644		
Horizon	AO	A1	A2	B	C	AO	A1	A2	B	A1	A2	B
Depth (inches)	0–2	2–15	15–36	36–58	58+	0–2	2–6	6–12	12–20	0–16	16–21	21+
	%	%	%	%	%	%	%	%	%	%	%	%
Coarse sand	36·5	38·5	35·5	28·9	9·3	70·5	63·5	57·0	20·5	53·5	51·0	14·5
Fine sand	56·5	54·5	53·5	29·3	62·2	16·5	19·0	19·0	12·5	34·5	37·0	13·5
Silt	3·0	4·0	5·5	7·0	6·0	5·0	6·0	6·5	10·0	7·5	7·5	15·5
Clay	4·0	3·0	5·5	33·8	22·5	8·0	11·5	17·5	57·0	4·5	4·5	56·5
Gravel	0	0	84	0	0	0	14	63	41	0	0	0
P_2O_5	—	·0041	—	·0077	—	—	·008	—	—	·008	—	—
Nitrogen	·069	·0079	·027	·019	—	·056	·021	·030	·036	·03	—	·06
Reaction pH	5·7	6·3	6·5	5·8	5·1	5·9	6·0	6·4	5·3	6·4	6·7	6·2

Truncated Lateritic Podsols and Deep Lateritic Sands

Locality	Cherry Gardens		Cherry Gardens				Blewitt's Springs		
Grid reference	670680		650670				502529		
Horizon	A2	B	A2	B1	B2	B3	A1	A2	A3
Depth (inches)	0–9	9–25	0–2	2–18	18–27	27+	0–6	6–14	14–36
	%	%	%	%	%	%	%	%	%
Coarse sand	33·7	1·8	19·0	1·5	2·4	0·6	88·5	84·5	83·2
Fine sand	43·6	10·8	36·5	14·0	12·6	15·7	8·5	12·0	13·3
Silt	13·7	14·2	28·5	20·0	25·0	28·2	1·0	1·0	1·0
Clay	9·0	73·2	16·0	64·5	60·0	55·5	2·0	1·5	2·5
Gravel	83	0							
P_2O_5	·021	—	—	·012	—	—	·0026		—
Nitrogen	·082	·028	·489	·062	—	—	·065	·039	·078
Reaction pH	5·6	5·7	6·7	6·1	5·3	5·0	5·2	5·5	3·0

Locality	Degraded Rendzina				Rendzina	Deep neutral sands			Unclassified				
	Reynella			O'Halloran Hill	Port Noarlunga	Noarlunga			Kangarilla		Seaview		
Grid reference	554642			560590	486575	526528			670550		584542		
Horizon	A1	A2	C	A	A				A	B	A	B1	B2
Depth (inches)	0–10	10–20	20+	0–36	0–5	0–15	15–20	20–36	0–2	2–30	0–18	18–24	24–36
	%	%	%			%	%	%			%	%	%
Coarse sand -	31·0	17·5	9·0	6·0	34·5	89·6	86·5	83·8	58·5	23·0	61·0	38·0	25·0
Fine sand - -	35·5	17·0	16·0	18·0	38·5	5·4	7·0	12·2	31·0	21·0	29·0	22·0	24·0
Silt - - -	11·5	17·5	17·0	13·8	13·0	1·0	2·0	1·0	4·8	2·0	4·0	4·0	6·0
Clay - - -	22·0	48·0	58·0	62·2	14·0	4·0	4·5	3·0	5·7	54·0	6·0	36·0	45·0
P_2O_5 - -	·062	—	—	—	·208	·0053	—	—	—	—	·044	—	—
Nitrogen - -	·207	·122	—	·068	·049	·014	·034	—	·247	·026	·040	—	·047
Reaction pH -	7·9	7·8	8·1	8·5	8·3	7·1	6·8	8·1	6·1	8·5	6·2	6·4	6·5

APPENDIX II

Comparative floristic lists are given for five major vegetational groups occurring within the area. No indication is given as to the percentage frequency of each plant, the x only indicating the presence of that species within that group. The nomenclature of the species is that given by Black (3). An asterisk before the name of a species indicates that the species has been introduced to South Australia.

	Life Form	E odorata association (1)	E. leucoxylon-E. viminalis assoc. (2)	Sclerophyll of E. odorata-E. leucoxylon-E. fasciculosa ecotone (3)	Casuarina stricta association (4)	Stringybark edaphic complex (5)
Adiantum aethiopicum	H	·	·	·	·	x
Cheilanthes tenuifolia	H	x	x	x	x	x
Pteridium aquilinum	G	·	·	x	·	x
Pleurosorus rutaefolius	H	·	·	·	x	·
Callitris propinqua	M.	·	·	x	x	-
C. tasmanica	M	·	·	·	·	x
Themeda australis	Ch	x	x	x	x	x
Neurachne alopecuroides	H	x	·	·	·	x
*Ehrharta longifolia	H	·	·	x	·	·
Stipa variabilis	H	x	x	x	x	x
S. setacea	H	x	x	x	·	x
*Oryzopsis miliacea	H	x	x	·	·	·
*Aira caryophyllea	H	x	x	·	·	·
*Avena fatua	H	x	x	·	·	·
*Holcus lanatus	H	·	·	·	·	x
Danthonia spp.	H	x	x	·	x	x
Enneapogon nigricans	H	·	·	·	x	·
Briza maxima	H	x	x	x	·	x
B. minor	H	x	x	x	·	·
Distichlis spicata	H	x	·	·	·	·
*Vulpia myuros	H	x	x	·	·	·
*Bromus spp.	H	x	x	·	·	·
*Cynodon dactylon	H	x	x	·	·	·
*Lolium spp.	H	x	x	·	·	·
*Hordeum murinum	H	x	x	·	·	·
Cyperus vaginatus	H	·	·	·	·	x
Scirpus nodosus	G	·	·	·	x	·
Lepidosperma laterale	Ch	·	·	x	·	x
L. viscidum	Ch	·	·	·	·	x
L. semiteres	Ch	·	·	x	·	x
L. carphoides	Ch	·	·	x	x	x
Chorizandra enodes	Ch	·	·	·	·	x
Hypolaena fastigiata	H	·	·	x	·	·
Juncus pallidus	H	x	x	x	x	x
Dianella revoluta	G	x	x	x	x	x
Reya umbellata	G	x	x	x	·	x
Anguillaria dioica	G	x	x	·	·	x
Lomandra dura	Ch	·	x	x	·	x

	Life Form	E odorata association	E. leucoxylon-E. viminalis assoc.	Sclerophyll of E. odorata-E. leucoxylon-E. fasciculosa ecotone	Casuarina stricta association	edaphic complex Stringybark
		(1)	(2)	(3)	(4)	(5)
Thysanotus Patersonii	G	.	.	.	.	x
T. dichotomus	G	.	.	x	.	.
Caesia vittata	G	.	.	.	.	x
Bulbine bulbosa	G	x	x	x	x	x
Dichopogon fimbriatus	G	.	.	x	.	.
Bartlingia sessiliflora	H	.	.	.	.	x
Xanthorrhoca quadrangulata	M	.	.	.	x	.
X. semiplana	Ch	.	.	x	x	x
*Asphodelus fistulosus	G	x	x	.	.	.
Hypoxis glabella	G	.	x	.	.	.
Calostemma purpureum	G	x	x	.	.	.
*Sparaxis tricolor	G	x	x	x	.	x
*S. bulbifera	G	x	x	x	.	x
*Romulea rosea	G	x	x	.	.	.
*Homeria collina	G	x	x	.	.	.
*H. miniata	G	x	x	.	.	.
Patersonia longiscapa	H	.	.	.	.	x
Dipodium punctatum	G	.	.	.	.	x
Thelymitra aristata	G	.	.	.	.	x
T. antennifera	G	.	.	.	.	x
Acianthus exsertus	G	.	.	x	.	x
Lyperanthus nigricans	G	.	.	x	.	x
Eriochilus cucullatus	G	.	.	x	.	x
Caladenia dilatata	G	.	.	.	.	x
C. deformis	G	.	.	.	.	x
Glossodia major	G	.	.	.	.	x
Diuris maculata	G	.	.	.	.	x
Pterostylis nana	G	.	.	.	.	x
Casuarina stricta	M	x	x	x	x	x
C. striata	M	.	.	x	.	x
C. Muelleriana	M	.	.	x	.	x
Isopogon ceratophyllus	N	.	.	x	.	x
Adenanthos terminalis	N	.	.	x	x	.
Conospermum patens	N	.	.	x	.	x
Persoonia juniperinum	N	.	.	.	.	x
Hakea rostrata	M	.	.	x	.	x
H. rugosa	N	.	.	x	.	x
H. ulicina	M	.	.	x	.	x
Banksia marginata	M	.	.	x	x	x
B. ornata	N	.	.	.	.	x
Grevillea lavandulacea	N	.	.	x	x	x
Exocarpus cupressiformis	M	.	.	x	x	x
Loranthus Miquelii	E	x	x	x	x	x
L. exocarpi	E	x	x	.	x	.
*Rumex crispus	T	x	x	.	.	.
*R. acetosella	T	x	x	.	.	.

	Life Form	E odorata association	E. leucoxylon-E. viminalis assoc.	Sclerophyll of E. odorata-E. leucoxylon-E. fasciculosa ecotone	Casuarina stricta association	Stringybark edaphic complex
		(1)	(2)	(3)	(4)	(5)
Muehlenbeckia adpressa	N	.	.	x	x	.
Carpobrotus aequilaterale	S	.	.	.	x	.
Ranunculus lappaceus	H	.	x	.	.	.
Cassytha glabella	E	.	.	x	.	x
Drosera binata	T	x	x	x	x	x
D. glanduligera	T	x	x	.	.	x
D. Whittakeri	G	x	x	x	.	x
D. Planchonii	G	.	.	x	.	x
D. auriculata	G	.	.	x	.	x
D. peltata	G	.	.	x	.	x
Crassula Siebariana	T	.	.	.	.	x
Bursaria spinosa	M	x	x	x	x	x
Marianthus bignoniaceus	N	.	.	.	.	x
Cheiranthera lincaris	N	.	.	.	.	x
Billardiera cymosa	N	x	x	x	.	x
*Rubus fruticosus	N	x	x	.	.	x
*Rosa canina	N	x	x	.	.	.
*Crataegus monogyna	N	x	x	x	.	.
Acaena ovina	H	x	x	.	.	x
A. sanguisorbae	H	x	x	.	.	x
Acacia continua	M	.	.	.	.	x
A. armata	M	x	x	x	x	.
A. obliqua	M	.	.	.	.	x
A. spinescens	M	.	.	.	.	x
A. verniciflua	M	.	.	.	.	x
A. rhetinodcs	M	.	x	.	.	x
A. myrtifolia	M	.	.	x	.	x
A. pycnantha	M	x	x	x	x	x
A. rupicola	M	.	.	.	.	x
A. vomeriformis	M	.	.	.	.	x
A. melanoxylon	M	.	.	.	.	x
Daviesia corymbosa	N	.	.	x	.	x
D. ulicina	N	.	.	x	.	x
D. brevifolia	N	.	.	.	.	x
Eutaxia microphylla	N	.	.	x	.	x
Pultenaca daphnoides	N	.	.	.	.	x
P. pedunculata	N	.	.	.	.	x
P. largiflorens	N	.	.	x	.	x
P. involucrata	N	.	.	.	.	x
P. acerosa var. aeicularis	N	.	.	.	.	x
Dillwynia hispida	N	.	.	x	.	x
D. floribunda	N	.	.	.	.	x
Platylobium obtusangulum	N	.	.	x	.	x
*Ulex europaeus	N	x	x	.	.	x
*Cytisus canariensis	N	x	x	x	.	x
*Trifolium procumbens	T	x	x	.	.	.

	Life Form	E odorata association (1)	E. leucoxylon-E. viminalis assoc (2)	Sclerophyll of E. odorata-E. leucoxylon-E. fasciculosa ecotone (3)	Casuarina stricta association (4)	Stringybark edaphic complex (5)
*T. subterraneum	T	x	x	.	.	.
*T. arvense	T	x	x	.	.	.
*T. angustifolium	T	x	x	x	.	.
Psoralea patens	Ch	x	.	.	.	.
Swainsona oroboides var. hirsuta	H	x	x	.	.	.
Kennedya prostrata	N	x	x	x	x	x
Hardenbergia monophylla	N	x	x	.	.	x
Glycine clandestina	H	.	.	.	.	x
*Erodium botrys	T	x	x	.	.	.
*E. moschatum	T	x	x	.	.	.
*Oxalis corniculata	G	x	x	.	.	.
*O. cernua	G	x	x	.	.	.
*Linum marginale	H	.	x	.	.	.
*L. gallicum	H	.	x	.	.	.
Boronia caerulescens	N	.	.	.	.	x
Correa rubra	N	.	.	.	.	x
Tetratheca pilosa	N	.	.	x	.	x
Adriana Klotzschii	N	x	.	.	.	.
Stackhousia monogyna	Ch	.	.	.	.	x
Dodonaea viscosa	N	x	.	.	x	.
Spyridium parvifolium	N	.	.	.	.	x
S. spathulatum	N	.	.	.	.	x
S. vexilliferum	N	.	.	.	.	x
Cryptandra tomentosa	N	.	.	x	.	x
*Malva parviflora	T	x	.	.	.	.
Hibbertia sericea	N	.	.	x	.	x
H. stricta	N	.	.	x	.	x
H. acicularis	N	.	.	x	.	x
H. virgata	N	.	.	x	.	x
*Hypericum perforatum	H	.	x	x	.	x
Hybanthus floribundus	N	.	.	x	.	x
Pimelia spathulata	N	.	.	.	.	x
P. flava	N	.	.	x	.	x
P. octophylla	N	.	.	.	.	x
Lythrum Hyssopifolia	H	.	x	.	.	.
Leptospermum scoparium	N	.	.	.	.	x
L. pubescens	N	.	.	.	.	x
L. myrsinoides	N	.	.	x	.	x
Kunzea pomifera	Ch	.	.	x	.	x
Callistemon salignus	M	.	.	.	.	x
Melaleuca decussata	N	.	.	.	.	x
M. pubescens	M	x	.	.	.	.
Eucalyptus obliqua	MM	.	.	.	.	x
E. Baxteri	MM	.	.	.	.	x
E. odorata	MM	x	.	x	.	.
E. cosmophylla	MM	.	.	.	.	x